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APPLIED MECHANICS REVIEWS

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HYDRODYNAMIC IMPACT

V. G. SZEBEHELY

Missile and Space Vehicle Department
GENERAL ELECTRIC COMPANY
PHILADELPHIA, PENNSYLVANIA

INTRODUCTION

The aim of this paper is to acquaint the reader with the background of and accomplishments in the field of water entry. The survey will review the essential tools which are at the disposal of the designer, emphasizing the principles on which our present day techniques are based and their applications. Attention will be directed to papers of general interest, study of which might prove to be alleviatory regarding the reading of the well over two hundred publications in this field, many rediscovering a few basic principles.

Upon defining our technical subject and listing fields of applications, current theories and applicable physical principles are described. This summarizing part of the paper is followed by general comments regarding experimentations and design applications. A short literature survey is attached, which is divided into two major parts. First, papers of general interest are mentioned. This is followed by a review of the most significant publications related to seaplane landing, torpedo entry and ship slamming. A discussion of experimental papers concludes the literature survey. The last part of this review describes the present state of the art, points out fruitful areas of further work, and gives applications to missile and space technology.

IMPACT THEORIES AND ASSOCIATED PHYSICAL PRINCIPLES

Hydrodynamic impact refers to the early stages of the entry of a body into water. Maximum forces are developed very shortly following contact with the free surface of the water. These early stages are of utmost importance for the underwater trajectory of missiles, for the structural design of the outer skin, of the supporting structure, and of the interior (deceleration-sensitive) payload. The designer needs hydrodynamic impact information in connection with seaplane landing, missile and torpedo entry, surface ship and seaplane seaworthiness, just to mention the most frequent fields of application. Hydrodynamic principles used in analyzing problems of naval ballistics, seaplane impact and wave effects on ships or on stable structures are closely related. With the exception of the important problem of very high velocity impact (when the compressibility effects of the water become prominent), the underlying theory is the so-called incompressible free surface potential flow theory, and the solution of the various problems may be reduced to the determination of variable virtual masses associated with the entering bodies.

The generally accepted method of introducing the problem (and its solution for the simplest case) is as follows. Consider a body of mass M arriving at the horizontal water surface with a velocity v_0 normal to this surface, and compute the force acting on the body as it penetrates the water surface. The momentum conservation principle requires that the system consisting of the body and water preserve its total momentum. The momentum at the instant the body touches the surface is Mv_0. During penetration the velocity of the body is reduced ($v < v_0$) and its mass is increased due to the inertia of the water moving with it. This apparent increase of mass (m) is called the "momentum virtual mass" or "impact induced mass" and the momentum equation can be written as $Mv_0 = (M + m)v$. This equation is modified if external forces, such as gravity, lift, buoyancy, friction, etc., are expected to be significant. As the penetration proceeds the geometry of the submerged portion of the body changes, therefore m is not constant. The impact force at any instant is $-M\dot{v} = -v_0\dot{m}\,(1 + m/M)^2$ or $= +(m\dot{v} + \dot{m}v)$; both of these equalities are obtainable from the momentum conservation equation. The equations show that the force is determined by the instantaneous value of m and by its time derivative. Knowledge of the variable virtual mass is essential and besides obvious modifications for elastic effects (elasticity of the body and compressibility of the water), external forces, non perpendicular impact, etc., the solution of the problem depends on correct estimates regarding m.

At this point a mathematical formulation of the problem might be advantageous for two reasons: (1) The determination of the virtual mass is a well-known problem in potential flow and (2) the above formulation of the problem will give the impact force, deceleration and average pressure at any instant during impact but it will not furnish the pressure distribution on the body.

If viscosity and compressibility effects are neglected and the fluid motion is started from rest, the flow will be described by a potential function (φ) satisfying the Laplace equation. The boundary conditions complicate the problem by nonlinearities and time effects since the requirement of constant pressure on the free surface of the water is satisfied if, according to the Bernoulli equation, $(\text{grad}\ \varphi)^2 = 2\partial\varphi/\partial t$. Therefore the mathematical problem is finding the solution to an un-

steady potential flow involving nonlinear boundary condition, with the boundary shape (free surface) to be determined as part of the problem itself. This problem is extremely difficult and only few solutions exist for special cases. If the impact occurs in a very short time and therefore it can be considered an impulse, and if the deformation of the free surface is neglected, the boundary condition becomes $\varphi = 0$, to be satisfied on the original, undisturbed, free surface. This fact is the explanation for lens, ellipsoid, double wedge, etc. solutions which when applied to impact problems use the symmetry property offered by the $\varphi = 0$ line or surface. Upon obtaining the solution to the simplified problem one can find the piled up water (or wetting) correction and the free surface correction by integrating relative to time the vertical velocities of the surface particles. The problem, therefore, is reduced to substituting for the entered part of the body by a shape for which the potential flow is either known or can be found. The body which replaces the entering object changes its shape also, since at every instance its symmetry plane must be the undisturbed free surface.

The above incompressible potential flow considerations are not applicable to the entry of blunt bodies at high speed since the occuring phenomenon is dominated by compressibility effects. According to an approximate theory the trapped pressure wave ($p = \rho c v$) is responsible for the impact pressure (p) at the impact region. The large pressure is released when and where the local flow velocity (which depends on the shape and on the impact velocity v) is smaller than the wave velocity (c). From this it follows that the applicability of compressibility flow considerations depends both on the impact velocity and on the shape of the "nose section."

EXPERIMENTAL VERIFICATION AND DESIGN APPLICATIONS

If the reader feels that the analytical aspects of hydrodynamic impact are not *semplice*, he will find that laboratory or full-scale verifications are probably even more complex. The major impact test facilities are associated with the NASA, Langley Field, Va. (seaplanes), Naval Ordnance Test Station, Inyokern, Cal. (torpedoes), David Taylor Model Basin, Carderock, Md. (ships), and Naval Ordnance Laboratory, White Oaks, Md. (missile and ordnance components). Tests performed in other facilities will be mentioned in our literature survey.

The main purposes of experimentation are to obtain motion, load and structural information. Measuring the impact force or deceleration during entry is a formidable instrumentation problem, since frequency response, resolution, and structural deformation effects can significantly influence the results. Measurement of the pressure distribution, which is of real importance to the designer, is even more difficult and so is the experimental determination of spray and piled up water surface. It is not entirely incomprehensible that a well-performed theoretical analysis might be more reliable than experimental results. In fact, experimental results often show larger spread than different theoretical approaches—to the enjoyment of the participants of the eternal *affaire d'bonneur*.

Hydrodynamic impact calculations can be used with the greatest confidence in connection with seaplane design. The enormous amount of carefully performed experimental and theoretical work by the NASA resulted in much useful design information. In the field of missile and torpedo entry the progress shown is equally impressive, although some valuable papers may not have received wide distribution due to classification. High-speed entry, unusual shapes and conditions require intuition and no immediately applicable design information exists. Regarding impact of floating (ships) and fixed (e.g. Texas towers) water structures, work began circa five years ago.

LITERATURE SURVEY

General Concepts

Since von Kármán's (1) fundamental paper (a small but typical feather in his cap) on the subject, only few basically new physical concepts have appeared in the literature. The recognition of the importance of the role of the virtual mass and the use of the momentum conservation principle are clearly stated in his 1929 paper, together with a suggestion regarding compressibility effects. While von Kármán's paper was the first, mathematical details came with Wagner's (2) work published three years later. The basic idea of the mathematical treatment proposed by Wagner can still be recognized in recent papers. In his somewhat difficult-to-read publication he solved the impact problem of the two-dimensional symmetric wedge of small deadrise angle, discussed the concept of similarity solution, computed the piled up water surface, the pressure distribution, spray thickness, gave the equation of a constant force bottom and introduced a deadrise angle correction factor. It can be stated without exaggeration that von Kármán's physical picture and Wagner's mathematical treatment are still valid and useful, and form the basis of most later papers. It is interesting to note *exempli gratia* that Sedov (3), Monaghan (4) and Bisplinghoff (5) gave solutions for the large deadrise angle wedge problem which solutions agree better in some respects with Wagner's half-intuition half-analytical work than with experimental results (5, 6). The great variety of correction factors are reviewed by Monaghan (7). Three-dimensional effects are handled (by using aspect-ratio correction factors) by Crewe (8), Pabst (9) and Yu (10), the latter less known, nevertheless strongly recommended. Pabst's work is known and quoted in the literature because of his aspect-ratio factor; his sound considerations of elastic effects also deserve attention.

Outstanding theoretical contributions were made by Shiffman and Spencer (11, 12) in a series of papers treating sphere and cone impact, replacing the first by a lens, the second by an ellipsoid. Their clarification of the virtual mass concept as applied to impact is of importance. Similarity solutions originated by Wagner (2) are revived by them and also by Cooper (13). Trilling's (14) linearized solution allows for impact at an arbitrary angle. Pierson (15) investigates details of the spray root and Schnitzer (16) suggests an approximate method for computing the pressure distribution on impacting elliptic cylinders. Fabula (17) discusses the ellipse fitting method for two-dimensional impact, filling an obvious gap with his careful analysis. Weible's (18) summary of theoretical and experimental work related to a variety of body shapes, with careful and critical use, might aid the designer.

Almost all theoretical papers mentioned above summarize previous accomplishments and show how the work fits into the whole and how it is related to other papers. Nonetheless no comprehensive and detailed critical review of the theoretical work is known to this writer.

Special Subjects

Seaplane landing

Some of the aforementioned references by Monaghan, Pabst, and Schnitzer are closely related to seaplane landing problems. Comprehensive treatments directly applicable to design

problems are offered by Korvin-Kroukovsky (19), Kreps (20) who summarized correction factors, gravity, and frictional effects, by Mayo (21), and by Milwitzky (22), just to mention a few. Mayo's excellent review points out that if the impact velocity has a component along the keel, then momentum will be lost to the downwash behind the float and therefore momentum conservation is to be satisfied between the body, its virtual mass and the downwash. This generalization of the momentum conservation principle is missing in Wagner's work and might be considered a significant contribution, and differentiates between the classical two-dimensional approach and the practical three-dimensional problem. Milwitzky treats the problems of hydrodynamic load, motion and pitching moment, and studies the effect of weight, deadrise angle, trim angle, flight path angle, and of initial velocity. The introduction of an "approach parameter" facilitates the formation of a comprehensive and useful method. In spite of the advances made by workers in the field of seaplane landing theory, not enough design information exists today for large beam loadings and the consequent maximum-load-reducing effect of chine immersion.

Torpedo entry

Several of the aforementioned publications are applicable to torpedo and missile water entry (11, 12, 13, 14, 18), nevertheless, attention is called to specialized articles discussing the rigid body dynamics (whip) and other characteristic aspects of torpedo impact. A series of NAVORD-NOTS reports (23) are of considerable interest, along with a series of papers presented at the NOL Water Entry Symposium (24). The hydrodynamic phenomena and scaling laws associated with cavity formation at later stages of water entry are discussed by Birkhoff (25).

Ship slamming

Impact of the forebody of ships and boats in waves is called slamming. The top speed of surface vessels is not limited by the available horsepower but by the heavy sea behavior of ships since structural damage is often caused by the hull-wave interaction. In as much as hydrodynamic impact (slamming) is the factor which prevents arbitrary speed increase in waves, its military significance is obvious. Szebehely (26,27) and associates (28) contributed a series of theoretical and experimental papers establishing the hydrodynamic foundations. Thorough and significant experimental work was reported by Akita (29) and Ochi (30) studying ship form parameters influencing the slamming behavior and related structural problems. The effects of regular and irregular waves were investigated by Korvin-Kroukovsky (31), Lewis (32), and recently by Tick (33). The past few years' impressive progress uncovered several controversial questions, the majority of which can be settled by further careful experimentation and full-scale trials.

Experiments

As mentioned previously, experimental impact load measurements are somewhat easier to perform but have less practical significance than determination of pressure distributions. The direct method of impact load measurement uses a piezoelectric gage, spring or strain gage. Watanabe's (34) classical experiments, the Bureau of Standards' (35) work and Sydov's (36) paper might serve as basic references. The indirect force measuring resorts to deceleration determination by either recording the motion (and differentiating twice) or by using accelerometers. Richardson (37) compares these approaches in his study of cavity formation and ricocheting, while Bisplinghoff (5) compares his own experimental and theoretical results and presents pictures showing that Wagner's theory over-estimates the effect of the piled up water. Experimental and theoretical results are also compared by Weible (18) and Majer (38). Pressure distribution measurements performed in a thorough and systematic manner by the NACA staff (39) show that pressure peaks are located near the instantaneous water line—an agreement with the theory. Jones's (40) results in England show that elastic properties of the impacting body (in practically important cases) do not affect the magnitude of the pressure peak; only the mean pressure increases with increasing rigidity. Pressure measurements on full-scale seaplanes are described in (39,40), and on ships in (41). A detailed review of measurement techniques is presented in (42).

PRESENT TRENDS

It was the intention of this paper to familiarize the reader with the engineering aspects of water impact. It is clear that the requirements of modern weapon systems, making use of naval hydroballistics, confront the designer with problems of high-speed entry where compressibility effects, structural deformations and rigid body dynamics must be taken simultaneously into consideration. *In praesenti* the state of art is such that if the designer is faced with an unusual or new set of circumstances, he is forced to go back to the fundamentals, since no reliable, handbook-type formulas exist which would be a cure for all hydrodynamic impact problems.

The two major fields of application are missile and torpedo design, and ship and seaplane problems. The experiences of the Second World War necessitated the development of an all-weather fleet of ships and seaplanes, with one of the limiting design criteria furnished by wave impact. Modern misselery and space technology associated with recoverable manned or instrumented space capsules requires precise design information regarding water landing of impact-sensitive payloads. It is conceivable that the whole recovery system and several logistic aspects are critically influenced by the landing-generated loads. Thus, if wave impact or water entry is involved in a transportation, weapon or scientific research system, the impact effects might easily put over-riding restrictions on the design.

The present-day design problems mentioned above suggest two major areas of effort. Regarding missile and space technology a thorough experimental and analytical approach *inter alia* to the combined structural, rigid body dynamics, and hydrodynamics problem of high-speed impact seems to be the most rewarding subject of future research. The other area to be emphasized is the impact effect of random seas on seaplanes and ships. Undoubtedly this is another open field where significant and fructiferous contributions can be expected in the near future.

It is noted that the problems awaiting solution will not be found probably in the realm of *semper fidelis* incompressible potential flow. Instead of efforts to establish further solutions to the Laplace equation with nonlinear free surface boundary conditions, one might visualize programs of major engineering significance concentrating on the hydro-elasticity aspects of impact.

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Physics, General

Book—2180. Gray, D. E. (editor), American Institute of Physics handbook, New York, McGraw-Hill Book Co., Inc., 1957, xi + 1524 pp. $15.

This is one of the newest additions to the ever increasing number of good scientific handbooks, and is intended primarily for those employing physical methods in research, application and teaching. The many new discoveries and advances in knowledge of post-war years have been taken into consideration in selecting the most generally useful data for inclusion in the volume. The major divisions of physics are handled in seven sections, namely mechanics, acoustics, heat, electricity and magnetism, optics, atomic and molecular physics, and nuclear physics. Extensive tables of physical properties that accompany each section are ably supported by brief but well-written notes covering the fundamentals of each topic considered. Perhaps a minor weakness of the volume is that in trying to cover too many topics or topics that border an engineering science, (such as shock waves, architectural acoustics, electrical power, etc.) completeness has at times suffered in the cause of generality.

Interesting inclusions in the mechanics section are chapters on geodesy, seismology, oceanography and meteorology. Several aspects of fluid mechanics are also covered, including cavitation and compressible gas flow. Space physics receives attention in several sections, with chapters on astronomical data, electrical and magnetic properties of the earth and stars, and radio astronomy.

The sections on atomic and molecular physics and on nuclear physics are particularly valuable in that they present much new information that has heretofore been available only in scattered publications. Data on radioactive isotopes, for example, should prove to be most useful in certain engineering fields.

Generally, the book can be strongly recommended. For engineers, and particularly for those engaged in research and teaching, it is an ideal complementary volume to Perry's "Chemical Engineers Handbook," and Marks "Mechanical Engineers Handbook."

A. Whillier, South Africa

Analytical Methods in Applied Mechanics

(See also Revs. 2196, 2197, 2199, 2242, 2243, 2244, 2245, 2246, 2192, 2296, 2396, 2399, 2413, 2417, 2469, 2472, 2473, 2487, 2507, 2578, 2585, 2587, 2657)

2181. Egervary, E., A generalization of Purcell's method for the solution of linear systems of equations (in German), *Öst. Ing.-Arch.* **11**, 4, 249–251, Dec. 1957.

Paper presents the application of a special rank-diminishing operation of a matrix to the solution of linear equations by means of the process of iteration. It is also shown that the general method introduced involves the method of Purcell as a particular case. V. Kopriva, Czechoslovakia

2182. Aizerman, M. A., and Gantmacher, F. R., Determination of stability by linear approximation of a periodic solution of a system of differential equations with discontinuous right-hand sides, *Quart. J. Mech. Appl. Math.* **11**, 4, 385–398, Nov. 1958.

Originally published in Russian in *Prikl. Mat. Mekh.* **21**, 1957, paper proves two theorems on the stability of periodic solutions $z_i = \tilde{z}_i(t)$ of a system of differential equations

$$z_i = dz_i/dt = f_i(z_1, z_2, \ldots z_n, t) \qquad [1]$$

where the f_i are periodic functions of t which are discontinuous at some points along the integral curve. These theorems, which are analogous to those of Lyapunov on stability by linear approximation in the continuous case, are:

Theorem 1. If the zero-solution of a system of linear approximation $\dot{x}_i = \sum_k (\partial f_i/\partial z_k)_{z=\tilde{z}(t)} x_k$ is asymptotically stable, then a periodic solution $z_i = \tilde{z}_i(t)$ of the initial nonlinear system [1] is also asymptotically stable.

Theorem 2. If the absolute value of at least one of the roots of the characteristic equation of linear approximation is larger than unity, then the periodic solution $z_i = \tilde{z}_i(t)$ of system [1] is unstable.

The conditions which the discontinuities of f_i must satisfy are carefully stated. R. E. Street, USA

2183. Copson, E. T., On the Riemann-Green function (in English), *Arch. Rational Mech. Analysis* **1**, 4, 324–348, July 1958.

This paper reviews the present position in finding the Riemann-Green function, a certain subsidiary function which is used to solve a partial differential equation of hyperbolic type of second order in two independent variables: $U_{xx} - U_{yy} + 2aU_x - 2bU_y + cU = 0$.

Six ways are discussed: (1) Riemann's original method and its generalisation; (2) method connected with Hadamard's elementary solution; (3) the integral equation method; (4) Chaundy's method using symbolic operators and power series; (5) Mackie's method using contour integrals; and (6) Titchmarsh's direct solution of the characteristic boundary-value problem.

Enlightening concrete examples are given for each method. It is to be hoped that this review will promote the use of the powerful tool in practical applications. S. Moriguti, Japan

2184. Copson, E. T., On a singular boundary-value problem for an equation of hyperbolic type (in English), *Arch. Rational Mech. Analysis* **1**, 4, 349–356, July 1958.

The following special problem is treated: To find a solution of $U_{xx} + (2\alpha/x)\,U_x = U_{yy} + (2\beta/y)\,U_y$ where α, β are positive constants, such that (1) U and its first derivatives are continuous in $x \geqq 0$, $y \geqq 0$, (2) the second derivatives of U are continuous in $x > 0$, $y > 0$, (3) $U = f(x)$ when $y = 0$, $x \geqq 0$; $U = g(y)$ when $x = 0$, $y \geqq 0$; $f(0) = g(0)$. The singularity of the coefficients on the boundaries are of particular interest here.

With polynomial or analytic data $f(x)$ and $g(y)$ connected by a certain integral relationship, solutions can be built up by using the polynomial solutions of even degree and the hypergeometric solutions of odd degree.

If $f(x)$ and $g(y)$ are merely continuously differentiable functions, Riemann's method [see preceding review] will give us one solution depending only on $f(x)$ valid in $0 < y \leqq x$, a second depending only on $g(y)$ valid in $0 < x \leqq y$. In order to get the required continuity on $x = y$, it is proved to suffice to make U continuous, and this leads to a certain relationship between $f(x)$ and $g(y)$.

S. Moriguti, Japan

2185. Hersch, J., Contribution to the study of difference equations (in French), *ZAMP* **9a**, 2, 129–180, July 1958.

In the classical procedure of solving a differential equation by replacing the derivatives by finite differences and solving the resulting difference equation, exact solutions of the differential equation are obtained by this method if the differential equation has polynomial solutions. Since differential equations rarely have polynomial solutions, author seeks to increase the accuracy of approximate methods of solving differential equations in the general case by using a somewhat different procedure than the above-mentioned one. By constructing an appropriate distribution, author shows how a differential equation can be transformed into a corresponding difference equation. It is then shown how, in the case of an ordinary differential equation with constant coefficients, to construct a difference equation whose solutions are exactly the same as those of the differential equation. Author then applies the method to ordinary differential equations with variable coefficients and partial differential equations for membranes and clamped plates. The solutions obtained for these problems by this method were compared with those obtained by the classical methods and found to be more accurate in most cases. To understand the method some aspects of the distribution theory would have to be known. E. J. Scott, USA

2186. Kholodilin, A. N., Criteria of similarity (in Russian), *Tr. Leningr. Korablestroit. In-ta* no. 16, 161–164, 1955; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10402.

Results are given of experiments, in a series of scale-model tests, on constrained rolling of ships in smooth water. It was brought to light that the relative amplitude of the oscillations appears to be an universal function of the product of Strouhal-Froude numbers; some dependence on Reynolds numbers becomes apparent near the maximum of the relative amplitude. On the basis of the results obtained it is proposed to carry out the modelling for roll in accordance with the criteria of Froude and Strouhal; it is proposed to take the value of Reynolds criteria into account in the form of a correction to the relative thickness of the boundary layer. G. I. Barenblatt

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Book—2187. Arrow, K. J., Karlin, S., and Scarf, H., Studies in the mathematical theory of inventory and production, Stanford, Cal., Stanford University Press, 1958, x + 340 pp. $8.75.

This mathematical treatise is an indication that operations research (and in particular, inventory theory) is out of the adolescent phase. While the volume is not a handbook (it makes no pretense of being one), authors have presented a thorough mathematical analysis of inventory problems as a class of optimization problems. While this is not a book for the novice in operations research or the informed manager, the O. R. practitioner should find it an invaluable reference work.

The first chapter is required reading for all concerned with operations research and inventory theory. Professor Arrow's introduction discusses inventory in terms of Keynes' analysis of money as a commodity. The motives for holding cash, i.e. trans-

actions, precaution and speculation, are similar, if not identical, to those for holding inventory. Chapter II (The nature and structure of inventory problems) is a clear and concise report of the structure of inventory models, the important factors and the various types of analysis. This chapter should be required reading for students and practitioners. Chapter III is a summary of the approaches and the results obtained in the technical sections. The foregoing three chapters comprise Part I.

Parts II, III and IV (Optimal policies in deterministic inventory policies, Optimal policies in stochastic inventory policies, Operating characteristics of inventory policies) each consist of a series of chapters under the main subject heading. The chapters would stand alone. Together they present a more complete picture of the present state of inventory theory. Chapter 9 is devoted to an analysis of the Arrow-Harris-Marschak dynamic inventory model. Chapter 10 extends the model to include lead times. These two chapters are an important contribution to inventory theory. Part IV discusses simple policies and the methods for selecting optional policies from a group of possible policies. Inventory practice as typified by most present investigations follows this practice. Simple policies are preferred because they result in simple procedures; they allow predictions of future operating characteristics and they are often optional under many sets of plausible and realistic conditions. The chapter deals with a number of problems of a stochastic nature in terms of steady-state solutions; policies are discussed in considerable detail. One chapter (chap. 11) is devoted to optimal policies for hydroelectric operations which fall within the scope of the volume. Water, like money, can be treated as a commodity subject to inventory fluctuations.

While the presentations are mathematical and written at a high level of sophistication, the considerations and assumptions are not at all unrealistic. The practitioner might have preferred some practical examples, but volume is not intended as a collection of case studies. The authors, with admirable support by Messrs. M. J. Beckman, John Gessford, and Richard F. Muth, have written an important and original work. E. Koenigsberg, USA

Book—2188. Van Der Waerden, B. L., Mathematical statistics. (Basic studies in mathematical sciences in monographs with special regards to applications. Vol. 87) [Mathematische Statistik. Die Grundlehren der Mathematischen Wissenschaften in Einzeldarstellungen mit besonderer Berücksichtigung der Anwendungsgebiete. Band 87.] Berlin, Springer-Verlag, 1957, ix + 360 pp. DM 49.60.

Author follows the trend in modern statistics, where the probabilities are accepted as empirical values, the mathematical operations of which are based upon the axiom system by Kolmogoroff, and the significance of the results are investigated by tests.

The first six chapters deal with the mathematics and some of its basic application to statistics, including the empirical determination of distribution functions and Gauss' theory of errors with Student's test. Knowledge in differential and integral calculus and analytical geometry is required. For certain proofs of theorems, the theory of functions and Lebesgue's integration theory should also be known. In many cases, however, the proofs are replaced by references; but this should not be a drawback to a reader who regards this book as the introduction which it is intended to be. The next three chapters deal with the theory of estimation, using Gauss' least-square method and Fischer's method of the "maximum likelihood." Then a chapter follows in which the application of statistics to biological efficacy (bioassay) is described. Many of the more important tests such as Chi square, F- and Wilcoxon's tests are described in the next two chapters. The last chapter deals with some correlation theorems (Spearman, Kendall).

This book is in good logical order and the print is of commendable quality. Fifty well-chosen examples serve as illustrations of the theory. A little English-German dictionary of expressions used in statistics is included and should be of help to many readers. C. B. Ludwig, USA

2189. Lotkin, M., Experiments in the smoothing of data, *Quart. Appl. Math.* **16,** 2, 169-172 (Notes), July 1958.

Book—2190. Hobson, E. W., The theory of functions of a real variable and the theory of Fourier's series. Vol. I (third revised enlarged edition), xv + 736 pp, Vol. II (second revised enlarged edition), x + 780 pp., New York, Dover Publications, 1957. $3. per volume (Paperbound)

Book—2191. Bowman, F., Introduction to Bessel functions, New York, Dover Publications, Inc., 1958, x + 135 pp. $1.35 (Paperbound)

Book—2192. Hancock, H., Elliptic integrals, 2nd ed., New York, Dover Publications, Inc., 1958, 101 pp. $1.25 (Paperbound)

An unabridged and unaltered republication of the first edition (1917). Ed.

Book—2193. Hancock, H., Lectures on the theory of elliptic functions, 2nd. ed., New York, Dover Publications, Inc., 1958, ix + 498 pp. $2.55 (Paperbound)

An unabridged and unaltered republication of the first edition (1909). Ed.

Book—2194. Forder, H. G., The foundations of Euclidean geometry, 2nd ed., New York, Dover Publications, Inc., 1958, xii + 349 pp. $2 (Paperbound)

An unabridged and unaltered republication of the first edition (1927). Ed.

Book—2195. Sommerville, D. M. Y., The elements of non-Euclidean geometry, 2nd ed., New York, Dover Publications, Inc., 1958, xvi + 274 pp. $1.50 (Paperbound)

An unabridged and unaltered republication of the first edition (1914). Ed.

Computing Methods and Computers

(See also Revs. 2185, 2222, 2236, 2283, 2303, 2429, 2639)

2196. Greenspan, D., On the numerical solution of n-dimensional boundary value problems associated with Poisson's equation, *J. Franklin Inst.* **266,** 5, 365-372, Nov. 1958.

Three theorems on solution uniqueness, convergence and truncation error for the second-order finite difference approximation equations are demonstrated. C. L. Perry, USA

2197. Diaz, J. B., On an analogue of the Euler-Cauchy polygon method for the numerical solution of $u_{xy} = f(x, y, u, u_x, u_y)$ (in English), *Arch. Rational Mech. Analysis* **1,** 4, 357-390, July 1958.

This paper develops, with an eye on the numerical applications, an analogue of the classical Euler-Cauchy polygon method (which is used in the solution of the ordinary differential equation $dy/dx = f(x, y)$, $y(x_0) = y_0$) for the solution of the following characteristic boundary-value problem for a hyperbolic partial differential equation

$$u_{xy} = f(x, y, u, u_x, y_y),$$
$$u(x, y_0) = \sigma(x),$$
$$u(x_0, y) = \tau(y),$$

where $\sigma(x_0) = \tau(y_0)$. The method presented here, which may be roughly described as a process of bilinear interpolation, has the

advantage over previously proposed methods that only the tabulated values of the given functions $\sigma(x)$ and $\tau(y)$ are required for its numerical application. Particular attention is devoted to the proof that a certain sequence of approximating functions, constructed in a specified way, actually converges to a solution of the boundary-value problem under consideration. Known existence theorems are thus proved by a process which can actually be employed in numerical computation.

From author's summary by S. Moriguti, Japan

2198. Dix, C. H., The numerical computation of Cagniard's integrals, *Geophysics* **23,** 2, 198-222, Apr. 1958.

The numerical calculation may be made in such a manner as to make clear the influence of various factors on the results. This is done for the buried source and receiver in a semi-infinite elastic medium. The process is to alter the path of integration so that with increasing time one increases the integration path length. Thus the total field unfolds as the integration is carried out.

The work is done graphically. The path is mapped by an electrolytic tank technique suitably modified from that used by electric network synthesis workers. The integrand is separated into a product of two terms, one independent of time and position and one dependent on time and position. This independent term can be mapped on a conducting sheet for one Poisson ratio. The dependent term may be mapped for each time and position.

A function multiplier and integrator are needed. The method is most accurate when the horizontal distance of the receiver is not very large compared with the sum of the depths of the source and receiver. The method is alterable to include the domain of difficult direct application.

Every aspect of the methods herein described may be extended in the practical sense to the more general case treated by Cagniard. This is, in fact, the main justification for this study of an old problem.

A useful and ingenious work. Y. Sato, Japan

2199. Chou, C.-H., Least squares, *Indust. Engng. Chem.* **50,** 5, 799-802, May 1958.

Useful ideas are given on the limitation of the least-squares methods in chemical calculations and the pitfalls encountered in technical work. From author's summary

2200. Niemz, W., The application of digital computers for the solution of aerodynamic problems (in German), *Z. Flugwiss.* **6,** 2, 47-52, Feb. 1958.

Some of the computing programs developed by the firm of Heinkel for solving problems of flight dynamics are explained in brief. The advantage of the order sequence in these programs is shown in comparison with earlier suggestions by various authors. Furthermore, the present paper is intended to put forward the collaboration and the exchange of experience in applying electronic computers among those who actively engage in aeronautics.

From author's summary

2201. Kogan, B. Ia., Theory of nonlinear computing members operating on the basis of step-linear approximation (in Russian), *Avtomatika i Telemekhanika* **17,** 12, 1081-1091, Dec. 1956.

2202. Tocher, K. D., Techniques of multiplication and division for automatic binary computers, *Quart. J. Mech. Appl. Math.* **11,** 3, 364-384, Aug. 1958.

Highly mathematical paper is mainly of interest to logical designers in computer field. Argument centers on the observation that the time required for processing numbers in the arithmetic unit depends mainly on the number of non-zero digits in the binary representation. Author therefore investigates a novel modified ternary scale, designed to minimize the number of non-zero digits. Author demonstrates that a gain in speed of a factor 2 to 3, depending on the particular numbers, should be possible by basing a parallel multiplier on this new principle. Possibilities for constructing fast dividers are also discussed.

F. C. Roesler, England

2203. Symposium on computers in the chemical world—past, present, and future, *Indust. Engng. Chem.* **50,** 11, 1621-1666, Nov. 1958.

2204. Sherman, J., Development of digital computer applications, 1621-1622.

2205. Redding, J. W., Electronic data processing and management in the chemical and petroleum industry, 1622-1623.

2206. Phister, M., Jr., Controlling a process with a computer, 1624-1626.

2207. Woods, F. A., Simulation of process control with an analog computer, 1627-1630.

2208. Williams, T. J., Analog computing in the chemical and petroleum industries—past and present, 1631-1635.

2209. Rogers, S., Analog computers and computing, 1636-1640.

2210. Waldo, W. H., and Barnett, E. H., An electronic computer as a research assistant, 1641-1643.

2211. Greenstadt, J., Bard, Y., and Morse, B., Multicomponent distillation calculation on IBM 704, 1644-1647.

2212. Dranoff, J. S., and Lapidus, L., Multicomponent ion exchange column calculations, 1648-1653.

2213. Orchard-Hays, W., Computers as tools for synthesis, experimentation and information handling, 1654-1656.

2214. Karplus, W. J., Bekey, G. A., and Pekrul, P. J., Atmospheric diffusion of air pollutants-analog computer study, 1657-1660.

2215. Hopper, G. M., From programmer to computer, p. 1661.

2216. Hubbard, L. C., Computers of the next generation—stretch, p. 1662.

2217. Miller, D. R., Computers of the next generation—analogs, 1662-1663.

2218. Grosch, H. R. J., The future of computing, 1664-1666.

Analogies

(See Revs. 2198, 2332, 2513)

Kinematics, Rigid Dynamics and Oscillations

(See Revs. 2180, 2245, 2246, 2325, 2419, 2421, 2426, 2428, 2690)

Instrumentation and Automatic Control

(See also Revs. 2302, 2324, 2429, 2520, 2566, 2667)

Book—2219. Considine, D. M., editor, Process instruments and controls handbook, New York, McGraw-Hill Book Co., Inc., 1957, xxiii + 1383 pp. $19.50.

Book represents an ambitious effort to cover practically the entire field of industrial instrumentation in a single volume. Although process industries are the primary concern, the contents should be equally useful in other fields, such as medical, military, or aeronautical instrumentation. Text is divided into 13 sections, each of which is divided into a number of chapters prepared by one or more authors.

In the introductory Section 1, outlining the scope of the book, it is emphasized that contents are confined to techniques for measurement of quantities required in processing work and to those means whereby automatic control can be accomplished. Automatic data processing and computation devices are excluded. The rest of this section offers a brief discussion of primary and derived standards. Section 2 deals with temperature measurement and covers thermocouples, radiation and optical pyrometers, resistance thermometers, thermistors, gas- or liquid-filled systems, and a number of other types. Section 3, on pressure measurement, deals both with mechanical sensors such as liquid columns, bellows, and Bourdon-spring elements, and with strain gages and other electrical transducers for steady and transient pressures. One quarter of this section is devoted to high-vacuum measurement. In Section 4, many types of head flowmeters and area flowmeters are treated, and there are also chapters on positive displacement meters, weirs and flumes for open-channel measurements, and mass and magnetic flowmeters.

Section 5 treats level detectors for liquids and solids. Section 6 deals with measurement of chemical composition and includes such subjects as spectroscopy, colorimetry, pH measurements, techniques based on thermal conductivity or on the absorption of some radiation, mass spectrometry, gas analysis, and polarography. Brief mention is made of nuclear magnetic resonance and electron paramagnetic resonance techniques and of x-ray diffraction methods. Comparison of the characteristics of over 100 techniques is presented in large fold-out charts.

Other process measurements are discussed in Section 7, which includes industrial weighers, tachometers, accelerometers, techniques for the measurement of density, humidity, viscosity, consistency, and photometric variables. Section 8 deals with many types of indicating and recording instruments and Section 9 with automatic controllers and timers. Section 10 contains a discussion of final control elements, such as valves and actuators, and their characteristics.

Section 11 deals with principles of automatic control and the first half comprises a nonmathematical introduction to the subject. The second half presents a more advanced discussion. This is the only chapter where more than elementary mathematical techniques are involved. Laplace-transform method is briefly introduced and extensively used in the analysis of the response characteristics of a variety of systems. Brief mention, essentially limited to representative references, is made of related subjects, such as statistical and sampling techniques and the treatment of nonlinear systems.

Section 12 contains nearly 100 tables of useful reference data such as electrochemical data, orifice coefficients for flowmeters, physical properties of materials, and thermocouple tables. Section 13 is a glossary of over 1000 important terms. All chapters are provided with adequate bibliographies. There is a well-prepared index of 51 pages which is an essential feature for a work of this type.

The text is well written and the use of many instruments is illustrated by typical examples. Emphasis is placed on operating principles, and descriptions of specific commercially obtainable instruments are merely illustrative examples. Unfortunately there are frequent instances of treating the same material in different sections instead of making cross references. Some authors provide a list of symbols for their chapter, while others prefer to identify symbols after every equation. In the latter case, the symbol may be defined twice on one page and, in a few instances, the same symbol may be given different meanings within one chapter. Only a small number of misprints were noted. Most of them are inconsequential, but it should have been stated that the analysis of the bridge circuit in Fig. 8 (page 2-57) is valid only if R_1 and R_3 are equal. In Eq. 5 (page 7-77), the pressure should be given in dyn/cm^2 and not, as stated, in gm/cm^2.

The stated criticisms should not detract from the value of the book, which contains a great wealth of information. This book should be important not only for people concerned with industrial instrumentation but also for research workers who have a variety of instrumentation problems. G. Rudinger, USA

Book—2220. Schuler, M., Introduction to the theory of automatic controls [Einführung in due Theorie der selbstatigen Regler], Leipzig, Akad. Verlagsgesellschaft, Geest & Portig K.-G., 1956, x + 278 pp. DM 24.

This is a well-written little book designed to present the fundamentals of automatic controls to students and practicing engineers who have no prior knowledge of the field. Details of construction are omitted to favor a more extensive theoretical treatment, which is kept as simple as possible for the intended audience by using classical methods of ordinary differential equations and systems of them with constant coefficients in preference to Laplace transforms or frequency techniques.

The classical methods are presented in some detail, including discussion of stability by the Routh-Hurwitz criteria, examination of the roots of the characteristic equation, factorization by a method of successive approximations (given in detail for equations including the sixth degree), and dependence of the roots on the coefficients of the characteristic equation. These methods are then applied to continuous controls with examples of pressure, temperature, flow and rotation controls without external power; and hydraulic and electrical controls with external energy and feedback.

The treatment of discontinuous controls is very brief in theory and example and is limited to two and three position, and periodic sampling controls. P. G. Kirmser, USA

2221. Johnston, W. G., Relating the Nyquist plot to the root-locus plot, *J. Electronics and Control* **5,** 1, 89-96, July 1958.

Author describes method for deriving Nyquist diagram from root-locus plot. Illustrations are shown which demonstrate how the point $KG(p)$ moves on the Nyquist diagram as (p) moves along contours parallel to the imaginary axis on the root-locus plot or (p) plane. Vectors drawn on the root-locus plot from points (p) on the parallel contours to roots of $KG(p)$ are manipulated to give magnitude and phase angle of $KG(p)$ necessary for drawing the Nyquist diagram. W. B. Spring, USA

2222. Dodo, D. J., The digital computer makes root locus easy, *Control Engng.* **5,** 5, 102-106, May 1958.

2223. Ulanov, G. M., Some applied methods for investigating linear systems of automatic control with variable parameters (in Russian), Sb. Statei po Avtomatike i Elektrotekhn., Moscow, Akad. Nauk SSSR, 1956, 42-62; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 9945.

Some examples are given of systems of automatic control, the transition processes in which are described by systems of linear equations with variable coefficients. The conditions of stability

were obtained for the evident solution of the equation

$$\sum_{i=0}^{n} (a_i + b_i t) \frac{d^i x}{dt^i} = 0 \qquad [6]$$

consisting in the fact that

$$Re S_i < 0 \quad (i = 1, \ldots, n)$$

where $S_1, \ldots, S_n$ are the roots of the equation

$$b_n s^n + \ldots + b_1 s + b_0 = 0$$

As an illustration of the possibility of applying Lyapunov's second method the problem is examined by the stability of the system

$$\frac{dx}{dt} = y, \quad \frac{dy}{dt} = -b(t)x + ay$$

a method which the author thinks is due to M. A. Eiserman. As a matter of fact the first results, devoted to the application of Lyapunov's method, are given in N. G. Chetaev's book "Stability of motion" and other works. Corresponding references are not cited in the paper. The possibility of application of Laplace's conversion is shown in the case of the following equation

$$\frac{d^2\varphi}{dt^2} + \frac{1}{t}\frac{d\varphi}{dt} - k^2\varphi = 0 \qquad [38]$$

Then V. V. Solodovnikov's and E. I. Chernov's results are demonstrated; these are based on the application of the theorem of "parcelling". In conclusion the possibility is indicated of the determination of the transition process with the aid of the impulse function based on Dumel's integral. No new results are given in the paper. B. S. Razumikhin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2224. Peschka, W., Stability investigations using the method of harmonic balance (in German), *Öst. Ing.-Arch.* **11**, 4, 276–285, Dec. 1957.

This review paper gives a concise and lucid explanation of the method of harmonic balance (known in USA as "Describing-Function Method") for investigating stability of a "mildly" nonlinear system. Several references are given to original papers, and some applications to physical systems are described.

T. P. Goodman, USA

2225. Anke, K., Three point control (in German), *Regelungstech*, **5**, 8, 262–264, 1957.

Paper is a theoretical study of the stabilization of on-off control systems in which the error-sensing device suffers from backlash, an inherent time lag, and a dead zone around the null position. The "three points" of the title refer to the three possible outputs of that device, namely, null and plus and minus unity. Such control systems are unstable under certain types of load. A method is proposed for the synthesis of compensating networks. These are lead networks which feed the error signal back to the input and are designed to simulate there the presence of a load without time constants (an ideal motor). It is shown that networks designed by this criterion produce near optimal behavior.

R. F. Drenick, USA

Book—2226. Bower, J. L., and Schultheiss, P. M., Introduction to the design of servomechanisms, New York, John Wiley & Sons, Inc., 1958, xi + 510 pp. $13.

This textbook, very illustrative in a single volume, covers subjects from introductory mathematics to higher treatments such as statistical considerations and nonlinearities. A separate chapter is allocated to the root-locus technique which is found quite useful in design work. A wealth of problems is given at the end of each chapter. To facilitate understanding and application an appendix, entitled "Some servomechanism components and their transfer functions," is given which is also very interesting. Illustrations are abundant and helpful for understanding. Misprints are few.

A sole shortcoming, if any, is found in the lack of chapter and article number at each page heading, which results in some difficulty in locating relevant equations referred to in later pages.

M. Sanuki, Japan

2227. O'Donnell, C. F., Inertial navigation, I and II, *J. Franklin Inst.* **266**, 4, 257–277, Oct. 1958; **266**, 5, 373–402, Nov. 1958.

This article is undoubtedly a useful addition to the comparatively small number of comprehensive articles on inertial guidance. While covering the usual range of material it also deals in a very concise form with such additional items as choice of coordinate systems and aided inertial systems. The method of error analysis is also very clearly presented. J. Solvey, Australia

2228. Stieglitz, W. I., Control and stabilization system reliability, *AGARD Rep.* 193, 17 pp. + 10 figs., Apr. 1958.

Paper discusses the design, ground testing and flight testing of control and stabilization systems, comparing past and present requirements. Author reviews the need for power controls and stability augmentation systems and discusses methods of testing and analysis used in evaluating reliability, which must be a major consideration throughout design. Photographs of test equipment are included. From author's summary

2229. Williams, T. J., Chemical kinetics and the dynamics of chemical reactors, *Control Engng.* **5**, 7, 100–108, July 1958.

The dynamic behavior of the more common chemical reactor systems and the reaction systems involved are discussed in detail. The application of automatic control to these different reactors is outlined. The ways to achieve the best combination of reactor and control system and the optimum yield from the chemical reaction are considered. L. Lapidus, USA

2230. Kruger, H., Detectors for the measurement and control of the temperature of rotating drums and drying cylinders (in German), *Regelungstech.* **6**, 5, 167–173, 1958.

Detectors known up to now are unsuitable for the temperature control of rotating drums and drying cylinders. Measurement in the past was treated as a static problem, whereas nowadays it is realized that it is necessary to keep track of dynamic processes with a minimum of delay. A satisfactory control system for this application has now been designed. From author's summary

2231. Cameron, R. J., Valve with a memory handles logic circuits, *Prod. Engng.* **29**, 21, 76–79, May 1958.

2232. Huddleston, F. J., Data file 15—Graphical analysis of hydraulic servos, *Control Engng.* **5**, 4, 89–91, Apr. 1958.

2233. Sturmer, W., Determination of differential coefficients from controller time constants (in German), *Regelungstech.* **6**, 4, 139–142, 1958.

2234. Vandenberghe, L., Endurance tests on irreversible servocontrols (in French), *AGARD Rep.* 128, 6 pp., May 1957.

2235. Neumark, Yu. I., The dynamics of relay-type automatic control systems (mechanical automation systems with dry friction, control systems with constant speed hydraulic servomotors, and the like) (in Russian), Thesis, Inst. of Automation and Telemechanics, Akad. Nauk SSSR, Moscow-Gorky, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6354.

2236. Fel'dbaum, A. A., Use of computers in automatic control systems (in Russian), *Avtomatika i Telemekhanika* **17**, 11, 1046–1056, Nov. 1956.

Tables, Charts, Dictionaries, etc.

(See also Revs. 2180, 2586)

Book—2237. Iron and steel dictionary [Stahleisen-Worterbuch], Dusseldorf, Verlag Stahleisen, 1958, 265 pp.

A small but complete technical dictionary in German/English and English/German of terms applying to the steel industry. Covers all known technical terms and language of the art plus conversion factors and tables for metric, British and American units. 8000 entries are given. Book is edited by Verein Deutscher Eisenhuttenleute in collaboration with the Iron and Steel Institute. Ed.

Book—2238. Emin, I., editor, Russian-English glossary of solid state physics, New York, Consultants Bureau, Inc., 1958, 90 pp. $10. (Paperbound)

This glossary is a compilation of more than 3000 Russian terms and expressions taken from numerous articles on various topics in solid-state physics. It also contains terms found in representative texts covering general solid-state theory, crystallography, physics of metals, metallurgy, ferromagnetism, semiconductors, etc. From editor's preface

Book—2239. Robeson, P., Jr., editor, Russian-English glossary of acoustics and ultrasonics, New York, Consultants Bureau, Inc., 1958, xxiii + 170 pp. $10. (Paperbound)

This glossary is a compilation of terms and expressions taken from numerous articles on various topics in the fields of acoustics, electroacoustics and ultrasonics theory.

From editor's preface

Book—2240. Cooper, S. A., Concise international dictionary of mechanics and geology (English, French, German and Spanish), New York, Philosophical Library, Inc., 1958, viii + 400 pp. $6.

Volume contains some 6000 entries in the form of English topics with other language equivalents. Other language entries are referenced to the main list. Ed.

Book—2241. Perry, J. W., and Kent, A., Tools for machine literature searching. Vol. I. Semantic code dictionary; equipment; and procedures, New York, Interscience Publishers, 1958, xviii + 972 pp. $27.50.

Book is presented in four parts, with the first two being reserved for consideration of machine literature-searching systems in general and underlying basic principles. The particular set of procedures developed by the editors and authors are presented in the third part of the book. The fourth part presents the semantic code dictionary, whose evolution will, of course, continue as it is applied to additional fields and as new terms are developed in its fields of application. Ed.

Book—2242. Smith, D. E., History of mathematics. Vol. I. General survey of the history of elementary mathematics, New York, Dover Publications, Inc., 1958, xxii + 596 pp. $2.75. (Paperbound)

Book—2243. Smith, D. E., History of mathematics. Vol. II. Special topics of elementary mathematics, New York, Dover Publications, Inc., 1958, xi + 725 pp. $2.75. (Paperbound)

Book—2244. Parke, N. G., III, Guide to the literature of mathematics and physics, including related works on engineering science, 2nd ed. New York, Dover Publications, Inc., 1958, xviii + 436 pp. $2.49. (Paperbound)

A revised and expanded version of the first edition (1947).

Ed.

Book—2245. Alekseev, V. P., Mathematics and mechanics in the publications of the Academy of Sciences, USSR, Bibliography 2, 1936-1947 [Matematika i Mekhanika v Izdaniyakh Akademii Nauk, SSSR, Bibliografia 2, 1936–1947], Moscow, Publishing House of the Academy of Sciences, 1955, 515 pp. 17.35 rubles.

A comprehensive listing of 4530 papers and books in the fields of mathematics and mechanics published under the auspices of the Academy of Sciences during the period of 1936–1947. This listing is chronological, and cross-listings by author and topic are also provided. Topic listings in mechanics include: history of mechanics, theoretical mechanics, theory of elasticity, structural mechanics, plates and shells, stability, vibrations, plasticity, nonlinear elasticity, hydrodynamics, aerodynamics, gas dynamics, hydraulics, and automatic controls. In pure mathematics topic listings include: history of mathematics, algebra, theory of functions, complex variables, integral equations, differential equations, statistics, topology and geometry.

W. A. Nash, USA

2246. Portugali, V. B., Mathematics and mechanics in the publications of the Academy of Sciences, USSR, Bibliography 3, 1948–1952 [Matematika i Mekhanika v Izdaniyakh Akademii Nauk, SSSR, Bibliografia 3, 1948–1952], Moscow, Publishing House of the Academy of Sciences, USSR, 1957, 361 pp. 15.60 rubles.

A continuation of Bibliography 2. During the period 1948–1952 a total of 3857 papers and books in mathematics and mechanics were published by the Academy of Sciences. These are all listed alphabetically by authors' names in this volume. A topical cross-listing consisting of the same topics mentioned in the preceding review is also given. Also included is a list of dissertations offered during this period. W. A. Nash, USA

Elasticity

(See also Revs. 2274, 2286, 2288, 2289, 2290, 2291, 2304, 2309, 2311, 2335, 2336, 2342, 2358, 2372, 2378, 2400, 2417, 2422, 2425, 2514, 2718)

2247. Ericksen, J. L., and Truesdell, C., Exact theory of stress and strain in rods and shells (in English), *Arch. Rational Mech. Analysis* **1**, 4, 295–323, July 1958.

Very theoretical paper which is not immediately applicable to solution of practical problems, but a significant contribution to basic theory. Considering a body as collection of points and of directions associated with each point—an idea propounded by Duhem (1893) and developed by E. and F. Cosserat (1907–9)—authors construct for rods and shells a precise description of strain and stress without reference to particular coordinate system. The results of Hay (1942) for rods, and of Synge and Chien (1941) for shells, are obtained as special cases. Paper is very mathematical; tensor calculus is used throughout.

D. M. A. Leggett, England

2248. Smith, G. F., and Rivlin, R. S., Stress-deformation relations for anisotropic solids (in English), *Arch. Rational Mech. Analysis* **1**, 2, 107–112, Sept. 1957.

Paper is a continuation and generalization of the impressive work by these authors on the stress-deformation relations for anisotropic elastic media.

Consider a body whose points are described by coordinates X_i in a rectangular Cartesian coordinate system, and let the body undergo a deformation such that x_i are thereafter the coordinates.

Let $g_{ij} = (\partial x_k/\partial X_i)(\partial x_k/\partial X_j)$. Authors have previously shown [Smith and Rivlin, *Trans. Amer. Math. Soc.*; in press] that if the body is assumed to have a strain energy function W and is anisotropic, then W can be expressed as a polynomial in a number of polynomials in g_{ij}, each of which is invariant under the transformations which characterize the class of anisotropy considered.

In the present paper the existence of a strain-energy function is no longer assumed. Instead, it is assumed that the components of stress t_{ij} in the x_i system are polynomials in the gradients $\partial x_p/\partial X_q$. The way in which the symmetry of a given anisotropic material restricts the form of this dependence is then investigated for the monoclinic and rhombic crystal classes. Calculations for the remaining classes can be carried out in a similar way.

W. H. Pell, USA

2249. Ruet, V. I., Three-dimensional stability of plane lattices of certain types (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 9, 84–100, Sept. 1956.

Besides the title problem the paper is concerned also with plane lattices subjected to torsion. Author performed some experiments with models, from which it follows that the torsional rigidity of lattices is much higher than that of thin-walled beams of the same weight. Also on the basis of model tests, author questions the existing stability investigation methods of top chords of open bridges.

The influence of the distribution of ribs (struts) on the torsional rigidity and stability of thin-walled beams is also investigated. Author discusses successively the "space work" of lattices with linear articulations at the nodes and lattices with parallel chords, and compares the work of thin-walled beams and lattices. The torsional rigidity of triangular and rhombic lattice is computed. The next scheme is represented by a lattice whose cross members are connected with the horizontal members by means of spherical joints.

W. Wierzbicki, Poland

2250. Petcu, V., Determination of temperature stresses in reinforced concrete beams with variable sections (in Rumanian), *Indus. constr. Mater. constr.* **8**, 11, 636–643, Nov. 1957.

In most practical cases haunched beams are exposed to different temperatures on the top and the bottom, especially in roof and floor structures. These thermal conditions can seriously affect the strength of the beams. Following cases are investigated: (1) Fully restrained beam with haunch at one end; (2) similar unsymmetrical beam, one end simply supported; (3) symmetrical fixed beam with two identical haunches. Practical example—two-bay symmetrical frame, hinged beams rigidly connected with hinged columns of variable section—demonstrates the procedure of the structural analysis presented in this interesting paper.

J. J. Polivka, USA

2251. Kloppel, K., and Schonbach, W., Thermal stresses in rectangular plates (in German), *Stahlbau* **27**, 5, 122–125, May 1958.

Thermal stress distributions are given for a number of illustrative problems of rectangular plates; the type of temperature field considered is steady and varies only in a direction parallel to one pair of plate's edges. Emphasis is placed upon difference-equation techniques for the determination of the Airy stress function.

H. G. Hopkins, England

2252. Miller, D. R., Thermal-stress ratchet mechanism in pressure vessels, ASME Ann. Meet., New York, N. Y., Nov.–Dec. 1958. Pap. 58-A-129, 5 pp.

The combination of cyclic thermal stresses and sustained internal pressure in a vessel is shown to be a source of progressive expansion of the vessel if the stresses are sufficiently high. Criteria presented allow determination of limits to be imposed on stresses in order to prevent progressive expansion or to allow estimation of the expansion per cycle where stresses are sufficient to produce growth. The effect of strain-hardening of the metal on progressive reduction of the growth rate is discussed.

From author's summary

2253. Swann, R. T., Heat transfer and thermal stresses in sandwich panels, *NACA TN* 4349, 23 pp. + 2 tables + 7 figs., Sept. 1958.

Calculated maximum temperature differences between faces and calculated thermal stresses are presented for sandwich panels with a prescribed linear rate at one face and with the other face insulated. Effects of conduction and radiation are included. Maximum temperature differences between top and bottom faces are considerably less when both radiation and conduction are considered than when radiation is neglected. An equation is derived that relates the maximum temperature difference when conduction only is considered. An approximate method for including the effects of radiation in calculations of temperature differences is presented. Reviewer considers a small error crept into Eq. 3, as x (a distance) is subtracted from a dimensionless unit.

From the author's summary by G. Sved, England

2254. Goodman, S., Russell, S. B., and Noble, C. E., Effect of variation of emissivity of internal surfaces of heated box beams on temperature distribution, thermal stress and deflection, *Nat. Bur. Stands. Rep.* 5927, 11 pp. + 1 table + 8 figs., June 1958.

Transient temperature distribution histories, thermal stresses, and deflections were computed for 13 box beams uniformly heated along one cover. Various heating rates, geometries of beam cross section, and thermal properties were considered. Heat transfer was by radiation and conduction. Gaseous heat transfer and possible effects of yielding, creep, and buckling were neglected.

For maximum beam temperatures above 700–900 F, change in emissivity of the interior surfaces of the beam had an appreciable effect on the cover (but not the web) temperatures and, to an even greater extent, on the beam deflection. At maximum beam temperatures of 1200 F, an increase in interior surface emissivity caused an appreciable decrease of the maximum thermal stress.

A rough experimental check of temperature distribution and beam deflection was made for one case.

From authors' summary

2255. Jung, H., Determination of thermal stresses in unevenly heated furnaces (in German), *Öst. Ing.-Arch.* **11**, 4, 257–264, Dec. 1957.

First a steady temperature distribution is derived in a cylindrical tube of finite thickness for the following boundary conditions: Given are (a) Heat transfer coefficient and temperature on the outer surface of the tube, (b) amount of heat released inside the tube; and (c) temperature of surrounding medium. Of these quantities all are constant except the surface temperature which is supposed to vary in axial direction as well as along the circumference of the tube. A general solution in form of a double integral is derived, but considered not suitable for numerical calculations in most cases. Then a particular solution is developed for conditions prevailing in furnaces. With the temperature distribution known, the stresses are split into two parts: Those in a two-dimensional plane stress field and those in plates stressed for bending. Finally, approximate formulas for the stresses are obtained. A numerical example with conditions characteristic for furnaces shows that the ordinary stresses in a furnace are reduced by thermal stresses due to an unsymmetrical temperature distribution.

H. Schuh, Sweden

2256. Rzhanitsyn, A. R., Temperature stresses appearing in concrete dams due to the action of outside air temperatures (in Russian), Issledovaniya po Stroitel'noi Mekhanike, Moscow, Gos. Izd-vo Lit. po Str-vu i Arkhitekture, 1954, 24–42; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8265.

Use is made of the equation of linear creep, set out by the author in a previous study. An investigation is made of a single dimensional problem, applicable to a very large mass—an infinite semi-space, the temperature of which is given for its plane boundary, changing sinusoidally with time along the whole boundary. The temperatures within the mass are determined from the equation of heat conductivity. The solution of the problem leads to the integral equation

$$\frac{\sigma_x(t)}{H} + \int_{-\infty}^{t} K_1(t-\tau)\sigma_x(\tau)\,d\tau + \frac{\alpha}{1-\nu} A_n \exp(-\lambda_n z)\sin(w_n t - \lambda_n z) = 0$$

where $K_1(t)$ is the function of the influence of previous loading on deformation at a given moment of time t, H and ν are momentary modulus of elasticity and Poisson's coefficient, t is time, α the coefficient of linear temperature expansion of the body, R the thermal resistance of the concrete, c the specific heat capacity, w_n frequency of the temperature variation, A_n its amplitude

$$\lambda_n = \sqrt{\frac{Rcw_n}{2}}$$

The solution of this equation is obtained in the form

$$\sigma_x(t) = \frac{\alpha A_n \exp(-\lambda_n z)}{(1-\nu)\sqrt{\bar{A}_n^2 + (\bar{B}n + H^{-1})^2}} \sin(\lambda_n z - w_n t - \xi)$$

Here

$$\bar{A}_n = \int_0^\infty K_1(\psi)\sin w_n \psi d\psi$$

$$\bar{B}_n = \int_0^\infty K_1(\psi)\cos w_n \psi d\psi$$

$$\psi = t - \tau, \qquad \xi = \operatorname{arctg}\frac{\bar{A}_n}{\bar{B}_n + H^{-1}}$$

Function $K_1(t)$ is selected in the following form $K_1(t) = (ae^{-bt}/t^{1-d})$ where a, b, d are some constants of positive value when $0 < d < 1$.

M. M. Manukyan

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2257. Amiro, I. Ya., Determination of temperature stresses for a two-dimensional problem of the theory of elasticity (in Russian), *Sb. Tr. In-ta Stroit. Mekhan. Akad. Nauk USSR* no. 21, 44-50, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4574.

An examination of the temperature problem for the two-dimensional theory of elasticity, described by the equation

$$\nabla^2\nabla^2 F + \frac{\alpha E}{1-\nu}\nabla^2 t = 0$$

where F is the stress function and t is the temperature.

Representing this equation by finite differences, author examines the problem of stresses in the base slab of a concrete spillway dam with a given temperature field. Comparison of the results obtained from the solution of the two-dimensional and one-dimensional field differs slightly in one direction. It is possible to limit one's self to solution of the one-dimensional problem for sections sufficiently far from the ends.

P. M. Varvak

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2258. Morris, Rosa M., and Hawley, F. J., Torsion and flexure of solid cylinders with cross-sections transformable to a ring-space, *Quart. J. Mech. Appl. Math.* **11**, 4, 462-477, Nov. 1958.

Paper deals with the torsion and flexure of a solid cylinder of simply-connected boundary cross section which can be mapped on the ring-space between two concentric circles, the inner one being the transform of an inner slit or cut in the cross section which, however, is not a physical boundary of the cylinder. Solutions for the potential functions, torsional constant, and center of flexure are determined in the general case and particular values of these are found for the elliptic cylinder and a cylinder having a circular arc as internal cut. An error in a previous paper is found and the consequent results are corrected.

W. M. Shepherd, England

2259. Penzien, J., Torsional rigidity of box beams having multiple cut-outs, *J. Ship Res.* **1**, 4, 15-20, Mar. 1958.

Problem is simplified by replacing the plate containing the cut-outs with an equivalent solid plate. Condition of equivalence is that plates have equal strain energies when subjected to equal shear loadings. Strain energies are calculated in manner similar to the Levy method. Effect of end restraint against warping is derived and included in the results, which are plotted nondimensionally for various cutout sizes.

Experimental results were obtained for various cutout widths, one cutout length and one beam length. Agreement between theory and experiment is quite good.

L. Mordfin, USA

2260. Okubo, H., The torsion and stretching of spiral rods. III, (in English), *Rep. Inst. High Speed Mech., Tohoku Univ.* **9**, 81/90, 21-34, 1958.

The equations of equilibrium and compatibility in three dimensions are transformed, through a set of rotating axes, to those specific to the state of stress in a coiled rod in which the state of stress is independent of the position along the helix. The equations are approximated for large and for small angles of helix. Stress functions are established for the two limiting cases which simplify the solution of stress distribution. A method of successive approximation to the differential equations and the boundary conditions is proposed to determine the stresses.

As an application of the procedure an analysis is made of the stresses in a spring, which is an extension of a solution due to Göhner for a circular ring. Numerical results are obtained for the additional normal and shear stresses that exist as a result of the angle of helix.

J. E. Duberg, USA

2261. Chobanyan, K. S., Application of the stress function to the problem of torsion of prismatic rods made of different materials (in Russian), *Izv. Akad. Nauk ArmSSR, Ser. Fiz.-Matem., Estestv. i Tekh. Nauk* **8**, 2, 17-30, 1955; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10782.

The problem is investigated of the torsion of an elastic prismatic rod, composed of different materials soldered together along their lateral surfaces, by means of the stress function $F(x, y)$, which is analogous to Prandtl's stress function for use with homogeneous rods. It was shown that the stress function $F(x, y)$ inside each of the regions D_i of the transverse section of the rod, corresponding to the different materials, must satisfy Poisson's equation $\Delta^2 F = -2\mu_i$, where μ_i is the modulus of shear of the material in the corresponding region D_i. Function $F(x, y)$ on the contour of the transverse section of the rod must satisfy the condition $F = 0$, functions F_i and F_j on the line of separation of D_i and D_j must satisfy the condition F_i and F_j, and their normal derivatives: the condition

$$\frac{1}{\mu_i}\frac{\partial F_i}{\partial \nu} = \frac{1}{\mu_j}\frac{\partial F_j}{\partial \nu}$$

where ν is the direction of the external normal to the line of separation of regions D_i and D_j. It was shown that the theory of infinite systems of linear equations can be applied for the solu-

tion of concrete problems on the torsion of composite rods with the same amount of efficiency as would be the case if applied to problems of torsion of uniform rods. A generalized Bredt formula is obtained for the circulation of tangential stresses of composite rods

$$\int_C \frac{1}{\mu_i} \frac{\partial F\nu}{\partial \nu} ds = -2\Omega$$

where Ω is the plane of the region bounded by contour C.

It was shown that Prandtl's formula for the determination of rigidity for uniform rods when under torsion is correct and also for composite prismatic rods. As an example, the problem was solved of the torsion on a rod made up from two rods of rectangular cross section soldered along their lateral surfaces to form a T beam. It was fully demonstrated that the joining was regular in infinite systems, obtained in the process of solution for the arbitrary relation of the shear modulus μ_0 and the arbitrary dimensions of the transverse section of the rod being examined. Tables of rigidity and stresses are given for some values of μ_0 for cases with different geometrical parameters of the section.

N. O. Gulkanyan
Courtesy, Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2262. Gulkanyan, N. O., The bending center of prismatic rods with transverse sections in the shape of an isosceles triangle (in Russian), *Izv. Akad. Nauk ArmSSR, Ser. Fiz.-Matem., Estestv. i Tekhn. Nauk* **8**, 5, 29–39, 1955; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8157.

By using a method previously adopted by the author for an approximate solution of certain torsion problems, an investigation is made of the torsion of a prismatic rod with a transverse section in the shape of an isosceles trapezium

$$|\varphi| \leq \alpha, \qquad a_1 \leq y \leq a_2 \left(\varphi = \text{arc } tg \frac{x}{y}\right)$$

and, in particular, when $a_1 = 0$ in the shape of an isosceles triangle. As satisfying the differential equation for the stress function u and the boundary conditions $U = 0$, the slices $\varphi = \pm \alpha$ of the section, author tries to find function U, when $\alpha \neq {}^1/_4\pi, {}^1/_6\pi$, in the form of a series

$$U(r, \varphi) = \sum_{k=1}^{\infty} \cos \mu_k \varphi \, x$$

$$x \left\{ E_k r^{\mu k} + F_k r^{-\mu k} + \frac{A_k r^2}{9 - \mu_k^2} + \frac{B_k r^2}{4 - \mu_k^2} \right\} \qquad [1]$$

where $\mu_k = (2k - 1)\,\pi/2\,\alpha$ and A_k, B_k are certain known constants. The constants still remaining unknown E_k, F_k ($F_k = 0$ when $a_1 = 0$) are determined from the condition of the minimum mean quadratic error of variation of U from 0 on the boundary cuttings $y = a_1$, $y = a_2$, $|\varphi| \leq \alpha$. In so doing, author sets limits to the approximation of function U by the first term of series [1] (assuming that $E_k = F_k = 0$ when $k \geq 2$). Next, the center of deflection was determined by a known formula. Separately, and in analogous manner, cases $\alpha = {}^1/_4\pi, {}^1/_6\pi$ were examined.

P. P. Kufarev
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2263. Rozovskaya, B. A., Stress concentration during torsion in slotted rollers (in Russian), *Trudi Kievsk. Tekhnol. In-ta Legkoi Prom-sti* no. 7, 167–176, 1955; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8165.

The problem of torsion of two slotted rollers with rectangular teeth is solved by the network method. The angles of torsion of the rollers per unit of length are found and the maximum tangential stresses. The problem was studied earlier by K. G. Galimkhanov ["A method of sectorial cuttings in calculations for torsion of prismatic rods of non-circular section," *Avtoref. Diss. Kand. Tekhn. Nauk Ufinsk Aviats. In-t.*, Ufa, 1950].

B. N. Lopovok
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2264. Kroupa, F., Plane deformation in the non-linear theory of elasticity (in English), *Czechoslovak J. Phys.* **5**, 1, 18–29, 1955.

Paper deals with problem already solved in somewhat greater generality for the Mooney nonlinear elastic solid by R. S. Rivlin, *Phil. Trans. Roy. Soc.* (*A*) **242**, 173 (see sections 10–13), 1949. The two solutions appear to be in agreement. The problem is that of a long hollow rubber cylinder bonded on both surfaces to rigid tubes which are rotated by different amounts. This has relevance to a torsion damper.

R. Hill, England

Viscoelasticity

(See also Revs. 2269, 2286, 2359, 2360, 2366, 2395, 2436, 2748)

2265. Stowell, E. Z., A phenomenological theory for the transient creep of metals at elevated temperatures, *NACA TN* 4396, 20 pp. + 2 tables + 7 figs., Sept. 1958.

The phenomenological theory previously proposed in *NACA TN* 4000 [AMR **10** (1957, Rev. 3631] has been modified to yield transient creep curves by assuming that the metal consists of two phases, each with its own elasticity and viscosity. The extended theory satisfies the requirement that the transient creep is closely related to the subsequent steady creep. The family of creep curves for any metal can be obtained from a set of nondimensional curves and appropriate constants obtained from steady creep measurements, together with two additional constants which represent the difference between the phases. Author finds good agreement between theoretical and experimental curves for pure aluminum, gamma iron, lead and 7075-T6 aluminum alloy.

M. Holt, USA

2266. Kastner, S., and Schlosser, E., On the phenomenological theory of viscoelasticity (in German), *Kolloid Z.* **152**, 2, 116–121, 1957; **155**, 2, 97–106, Dec. 1957; **156**, 2, 142–150, Feb. 1958.

In the first part authors present elements of the linear scalar theory of the phenomenological theory of viscoelastic bodies. No restrictions are imposed on the material to which theory applies. Theory is formulated in a spectral form, which is capable of describing all viscoelastic phenomena of a material.

In the second part authors discuss the mechanical relaxation of viscoelastic bodies, when stress or, alternatively, strain is given. In their most general formulation the relations for these two cases are inconsistent. Result of discussion is a classification of materials, from which it is evident which experimental results can be explained by the phenomenological theory.

In the third part the linear theory for relaxation of anisotropic bodies is given. The viscoelastic behavior is in this case characterized by six tensors of valence four. The most important relations between these tensors are given.

From authors' summary by A. Isaksson, Sweden

2267. McComb, H. G., Jr., Analysis of the creep behavior of a square plate loaded in edge compression, *NACA TN* 4398, 36 pp. + 6 figs., Sept. 1958.

Deflections of a flat plate, simply supported at the edges and having small initial imperfections, are calculated assuming the material obeys a cubic uniaxial creep law. A variational theorem from *NACA Rep.* 1342 (1958), whereby stress rates and strain

rates are varied, is used. Initial conditions are obtained from an elastic solution. Numerical results are obtained using the Runge-Kutta method and a digital computer. Calculations based on small deflection theory yield a finite collapse time, but a more refined large deflection theory does not. A comparison with linear viscoelastic theory is also made. A. D. Topping, USA

2268. Hilton, H. H., On the reduction of maximum loads in nonlinear viscoelastic columns, *J. Aero. Sci.* **25,** 6, 399–400 (Readers' Forum), June 1958.

Author states, "... two interesting phenomena associated with nonlinear creep buckling have escaped attention so far and are the subjects of this paper—i.e., the reduction of the maximum nonlinear viscoelastic load as compared to the maximum load of an equivalent elastic column, and the nonoccurrence of a finite buckling time under some conditions." Conclusions are based on analysis of creep-buckling equations derived by Odqvist [AMR **8**, (1955), Rev. 1002], who assumed compressive creep rate $(d\epsilon/dt)$ at variable uniaxial stress σ to be $(d\epsilon/dt) = k_0\sigma^{n_0-1}(d\sigma/dt) + k\sigma^n$. In corresponding expression for tensile creep rate, Odqvist omitted the first term on the right.

Reviewer notes that the maximum nonlinear viscoelastic load is the ordinary "static" column strength. The reduction of this load as compared to the maximum load of an equivalent elastic column, the first point to which author calls attention, is the well-known reduction in static strength for an initially curved column of a material having a nonlinear static stress-strain curve.

Author's proof of nonoccurrence of finite buckling time for nonlinear viscoelastic columns under some conditions is based on his statement that Odqvist's solution does not give finite buckling time except when $n > 2$ and $n_0 < n$. Then a column made of material for which $n = 2$, or for which $n_0 \geq n$ would be a nonlinear viscoelastic column with no finite buckling time.

Reviewer believes a closer look at Odqvist's solution indicates a finite buckling time for any nonlinear viscoelastic column. Difficulty arises from the fact that solution gives a curve of deflection versus time that passes through a maximum time value, following which deflection increases while time appears to decrease. Solution is invalid for deflections exceeding value corresponding to point of maximum time on this curve. Failure should be considered to occur when rate of change of deflection with respect to time becomes infinite, and on this basis the Odqvist solution gives finite failure time for any nonlinear viscoelastic column with finite initial curvature or eccentricity. Author's method of calculating time to failure is to substitute an infinite deflection in the deflection-versus-time relationship. This gives erroneous results since solution is not valid for infinite deflections.

Incidentally, reviewer notes that Odqvist solution in form given is correct only for odd values of n. For even values of n, a sign must be changed in the tension stress-strain rate relationship so that negative (tensile) stress gives negative strain rate.

J. W. Clark, USA

Plasticity

(See also Revs. 2238, 2251, 2265, 2286, 2287, 2319, 2345, 2395, 2397, 2400)

2269. L'Hermite, M. R., What do we know about plastic deformation and flow of concrete? (in French), *Ann. Inst. Tech. Bat. Trav. Publics* **10,** 117, 778–809, Sept. 1957.

Author presents well-documented account of previous and his own extensive research on plastic deformation and creep of concrete. Effects of composition of concrete, method of storage, volume under stress, age at loading, magnitude of loading and unloading cycles and creep under different stress conditions are examined on basis of various test results. It is indicated that creep is a hydro-constrictive phenomenon dependent on water movement and covariant with shrinkage. State of deformation tends toward value proportional to stress under simple action or deviator stress under combined actions with a minimum corresponding to the shrinkage. Deformation follows law similar to viscosity, with rate of creep reducing as stressed volume increases and lateral creep is small under compressive stresses below one half of compressive strength. Under repeated loading below fatigue limit creep is accelerated. G. G. Meyerhof, Canada

2270. Kachanov, L. M., On plastic bending of curved thin-walled tubes (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 5, 42–47, May 1957.

Approximate analyses, based upon a variational technique, are given of the elastic-plastic deformations of curved, thin-walled, circular tubes under pure bending moments; the material is perfectly-plastic and obeys the von Mises' yield criterion.

H. G. Hopkins, England

2271. Ivlev, D. D., Bulging of a thick-walled tube, weakened by a shallow, axisymmetrical groove, (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 5, 113–118, May 1957.

A long, thick-walled, circular tube is weakened over a certain length by relatively shallow grooves cut in its inner and outer surfaces; axial symmetry and symmetry about a central normal cross section are supposed preserved. The problem considered is to discuss the strength of the tube under conditions of uniform internal pressure. Essentially, the presence of the grooves causes a perturbation in the known simple solution of the problem for a constant cross-section tube, perfectly-plastic elastic material being assumed. The new problem is one of axially-symmetric plastic-elastic deformation, and a rather general treatment is presented on the basis that the Haar-Karman heuristic hypothesis of plastic yielding is satisfied. No specific cases of the general problem are discussed. H. G. Hopkins, England

2272. Storchi, E., Linearization of the equations of plasticity for plane statically determinate problems (in Italian), *Atti Accad. Naz. Lincei R. C. Sci. Fis. Mat. Nat.* **23,** 1/2, 45–50, Feb. 1957.

Two parameters α and β can be chosen to represent the yield surface in σ_{xx}, σ_{xy} and σ_{yy} space. Author shows that, if α and β are taken as independent variables, then the coordinates x and y are given by two linear simultaneous first-order partial differential equations. Author has not considered how such results can be used to solve practical problems. D. R. Bland, England

2273. Hopkins, H. G., Some remarks concerning the dependence of the solution of plastic plate problems upon the yield criterion (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **6,** 448–457.

Paper concerns the dependence of the solution of plasticity problems upon the yield criterion in relation to plate theory. The material is taken to be ideal plastic-rigid and the plastic potential is assumed to coincide with the yield function. Attention is confined to the von Mises, the Tresca and the Johansen yield criterion, the first and the second applying to ductile metals, the third to reinforced concrete. The discussion is restricted to problems of rotational symmetry. A comparison is made between solutions of some relatively simple static and dynamic problems of thin circular plates. The results for the Johansen yield criterion are mainly new. It is found that the solution can be markedly dependent upon the yield criterion. F. Chmelka, Austria

2274. Sokolov, N. B., Creation of large deformations in elastic and plastic bodies (in Russian), *Trudi Penzensk. Industr. In-ta* no. 2, 131–153, 1954; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8218.

A formal generalization is presented of the principle of similarity in stress and deformation deviators known to occur in small

elastic-plastic deformations. Examples of calculations are examined for stresses at given transpositions in homogeneous deformations of bodies. There are misprints in the work. References to the abundant literature sources are not cited.

L. A. Tolokonnikov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2275. Gur'ev, A. V., Coefficient of transverse deformation in the plastic region (in Russian), *Fiz. Metallov i Metallovedenie* **2**, 3, 457–463, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8249.

Determinations were made of the coefficient of transverse deformation in the plastic region μ_n on 6 types of carbon steel in various conditions. Preliminary experiments showed that even in samples of cylindrical shape plastic deformation in the cross section flows irregularly and causes a large distortion in the shape of the section. Taking this into account the author, when determining the coefficient transverse deformation in the plastic zone, made use of the magnitude of the diameters of the samples, representing the mean of 24 measurements of previously selected sections and their direction. The diameter measurements were made with a sensitive lever micrometer with a precision of 0.001 mm. The longitudinal deformation was measured with a travelling microscope, with the same precision tolerance, on a 40-mm base. Measurement of the size of the plastic deformation was carried out two minutes after removal of the samples. After preliminary loading up to the outflow beyond the plane of flow, removal and deformation measurement, the samples again were deformed up to 5% and after removal the deformations were measured. For the determination of μ_n actual deformations in the longitudinal and transverse directions were used. The results of the experiments showed that μ_n, determined by means of the residual deformations after removal of the samples, for the tested steels has a value of 0.498, that is, deformation proceeds without change of volume. The divergence of value for various brands of steel equals 0.004 (less than 1%). In the last part of the paper an analytical investigation is pursued. As the result of the investigation the relation was established permitting the determination of the real coefficient of transverse general deformation on any portion of the tension curve without measuring the transverse deformations. This relation has the form

$$\mu_0 = 0.5 - 0.25\,\frac{D}{E}$$

where μ_0 is the coefficient of transverse deformation, reflecting the relation of the sum of the deformations (plastic and elastic); D is the hardening coefficient, E is the modulus of longitudinal elasticity.

V. G. Lyuttsau

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2276. Vasil'ev, V. G., Residual deflections in rod systems beyond the limits of elasticity (in Russian), *Trudi Khar'kovsk. In-ta Inzh. Zh.-d. Transp.* no. 26, 213–234, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4741.

Using Mor's method, determinations are made of the full and residual deflections of a single-span beam, of a three-hinged arch, and a two-span continuous beam for particular cases of loading. The sections of the beams and the arch are rectangular. Tables are given for the numerical values of the coefficients in the deflection formulas. For the arches, the influence of normal forces on the size of the residual deflections was investigated. The theoretical deflections were compared with the experimental. For a pure deflection the divergence between the theoretical and experimental deflections is very significant, in spite of the author's assertions.

Paper contains a number of vague statements; in particular it is not understood how, from a slab 1.4 mm thick, test beams with a thickness of 0.9–2.06 cm. could have been cut.

N. D. Zhudin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2277. Slavin, N. Ya., The problem of the calculation of prismatic folding by the non-moment theory (in Russian), *Nauch. Tr. Leningr. Inzh.-stroit. In-ta* no. 17, 159–171, 1954; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4621.

A graphical method is suggested for calculating folding systems with two-faced nodes and linear hinges on ribs for any simultaneous loading of all faces. A concrete example of the calculation is given.

A. K. Mroshchinskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2278. Rovinskii, B. M., and Lyuttsau, V. G., Structural changes in pure metals in the process of stress relaxation (in Russian), *Izv. Akad. Nauk SSSR, Ser. Fiz.* **20**, 6, 636–638, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 11126.

The structural changes were studied in Al (99.99%) and Cu (99.92%) in the processes of deformation and stress relaxation. The samples, preliminarily thermally treated in a vacuum oven to obtain the required grain size, were fastened on the bench of an x-ray camera and were loaded up to 0.1% of the longitudinal deformation. The resolving capacity of the apparatus was improved by using a collimation device in the shape of narrow cruciform (3.0×0.02 mm) and radial (2.5×0.01 mm) slotted arrangements. The distance from the slot to the sample was 120 mm, the distance of the sample to the film 240 mm. The flat film was placed normally to the reflected pencil of rays. The x-ray photographs were carried out on an ionic valve with a strongly diffused focus with irradiation from a copper anode. Reflections (511 and 333) of aluminum and (420) of copper were examined. The x-ray photographs were taken at 24-hr intervals and approximately 500 hours after deformation. The exposure time was 4 hrs. Analysis of the results enabled the authors to make the following deductions: (1) In the stress relaxation process in aluminum and in copper, irreversible structural changes appear in the crystals, similar to the changes occurring at small plastic deformations. (2) In conditions of stress relaxations at room temperature changes also take place in the mutual disposition of the crystals. (3) The reciprocal transfer of crystals is dependent on, in all probability, the viscous behavior of the boundaries of the crystalline particles.

V. M. Kardonskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2279. Quarrell, A. G., Fifty years of metallurgical science, *J. Inst. Metals* **86**, 475–484, 1957–58.

The appreciation of metals on an atomic scale is regarded as one of the outstanding developments in metallurgy during the past fifty years. Examples chosen to illustrate this are briefly described, including the phenomena of age-hardening, diffusion, alloy formation, plastic deformation, yield points, polygonization, and grain boundaries. The influence of modern physical metallurgy upon alloy development is then discussed, and it is concluded that the theoretical design of alloys with specified properties must await a proper understanding of the electronic structure of metals.

From author's summary

Rods, Beams and Strings

(See also Revs. 2247, 2258, 2259, 2261, 2262, 2307, 2330, 2337, 2338, 2339, 2355, 2397, 2408, 2417, 2427)

Book—2280. Iwinski, T., Theory of beams, New York, Pergamon Press, 1958, 85 pp. $3.50.

Book is written primarily for structural engineers and, according to the opening remarks, is intended to be the first item in a project on application of Laplace transformation method to static problems in the theory of structures. Although the title suggests a broader scope, the book is concerned entirely with common beam problems, formulated with assumptions of elementary beam theory, generally in the form of the usual fourth-order differential equation. In addition to such problems as simple, built-in, propped cantilever and continuous beams, the book treats the theorem of three moments and, for beams on elastic supports, a theorem of five moments.

It may be mentioned that the procedure of using Laplace transformations in basic beam problems is already covered, concisely but adequately, in such books as R. V. Churchill's "Operational Mathematics" (McGraw-Hill, second edition, 1958) and W. T. Thomson's "Laplace Transformation" (Prentice-Hall, 1950). The solution of beam problems by the direct calculus of step-functions and the extension of this method to statically indeterminate and continuous beams was discussed by this reviewer in "Application of Heaviside step-functions to beam problems," *Proc. Amer. Soc. Civ. Engrs.* **79,** Pap. 202, July 1953.

Reviewer believes that since the direct calculus of step-functions is a simpler technique than the Laplace transformation, it would be more attractive to structural engineers. However, this book may serve a useful purpose in calling attention of engineers to the availability and utility of modern mathematical methods for beam problems. J. E. Goldberg, USA

2281. Hanson, J. A., Shear strength of lightweight reinforced concrete beams, *J. Amer. Concr. Inst.* **30,** 3, 387–403, Sept. 1958.

2282. Clark, E. D., A rundown on the conjugate-beam method, *Prod. Engng.* **29,** 33, 83–85, Aug. 1958.

2283. Karrholm, G., A method of iteration applied to beams resting on springs (in English), *Trans. Chalmers Univ. Technol.* no. 199, 50 pp., 1958.

Differential equation is approximated by finite difference equations and resulting matrix equation is solved by iteration. Residuals arising from substitution of assumed deflection are shown to be analogous to damping forces on a beam in viscous medium where inertia forces of beam are neglected. Corrections on deflection are made proportional to residuals and are thus analogous to motion of beam during small time interval. Assumed deflection of beam is therefore sum of true deflection and exponentially decaying modes whose time constants are reciprocals of eigenvalues of matrix. For decrease of given viscous mode, time interval must be less than two divided by associated eigenvalue. If eigenvalues are known, optimum time interval for removal of given mode is time constant which is reciprocal of eigenvalue. Relaxation can start with larger time intervals for removal of grave modes but time intervals must be successively reduced to eliminate higher modes.

Method is applied to beams with transverse loads in linear and nonlinear cases and to vibration and buckling problems. Graphical iteration is described and used to find influence lines.

Method is useful for physical interpretation of convergence.
R. B. McCalley, USA

2284. Arakelyan, T. T., Deflection of an infinite beam on a continuous soil foundation (in Russian), *Izv. Akad. Nauk ArmSSR, Fiz.-Matem., Estestv. i Tekhn. Nauk* **9,** 3, 45–61, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8319.

An infinitely long prismatic beam is investigated; this is supported along its whole length on a continuous pliable water-saturated soil foundation and loaded with a single concentrated force. Under the continued action of the load the foundation reaction $q(x,t)$ is determined from the condition of the equality of the beam's deflection to the foundation's settlement in the presence of a rectilinear filtration consolidation of the soil of the foundation. The determination of the foundation reaction $q(x,t)$ merges with the solution of the integrodifferential equation

$$q(x,t) = \frac{8EIk_0}{\Delta Hb}\int_0^t \frac{\partial^4 q(x,\xi)}{\partial x^4}\sum_{\nu=1,3\ldots}^{\infty} e^{-\nu^2\lambda(t-\xi)}d\xi - \frac{P}{2}\beta(\sin\beta x + \cos\beta x)e^{-\beta x}$$

with some boundary and initial conditions. Here b, Δ, H, β, K_0, λ, E, I are some constants characterizing the physical properties of the beam and the soil, t is the time, x the abscissa of the beam's section. A general solution of the equation is sought by the author in the form

$$q(x,t) = X(x)\,T(t) - \frac{1}{2}P\beta\,(\sin\beta x + \cos\beta x)e^{-\beta x}$$

Having determined functions X and T and the arbitrary constants of the integration, author finds the final expression for the foundation reaction, the settlement of the foundation, the deflection moment and the shear. The results obtained are compared with the values of the self-same magnitudes obtained in the case of the elastic momentary problem. It is found that, with the exception of the maximum shear force, the remaining values, when taking into account the filtration consolidation of the soil of the yielding foundation, are significantly larger than in the case of the elastic momentary problem. A. G. Ishkova

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2285. Foppl, L., Foundation beam on elastically yielding soil (in German), *Forsch. Geb. Ing.-Wes.* **23,** 6, 201–209, 1957.

Simple beam theory is applied to elastic rods on elastic foundations for the cases of one or three symmetrically placed concentrated loads. Author distinguishes between cases where the length of beam exceeds the contact length and where it does not. Results agree well with photoelastic results.
F. T. Geyling, USA

2286. Kucherov, P. S., Influence of the time factor on the deformation of rocks (in Russian), *Dop. Akad. Nauk URSR* no. 6, 532–534, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10916.

The regularity of the deforming body is examined. The mechanical model used is in the form of a beam, placed on "elastic" and "viscous" supports, when the applied force is evenly transferred from the elastic to the viscous element. N. I. Malinin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2287. Geniev, G. A., Some problems of calculation for rods during a general nonlinear dependence of stress on deformation, Investigations on problems of structural mechanics and the theory of plasticity, Moscow, 1956, 188–222; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8242.

Based on the approximation of the relation between stress σ and deformation ϵ

$$\sigma = \sum_{n=1}^{m} r_n \sin k_n \epsilon$$

the following problems are investigated regarding the resistance of materials: deflection of a straight brace, torsion of a round shaft, eccentric compression, stability of a centrally compressed rod, the simplest cases of statically indeterminate problems of tension and compression. L. M. Kachanov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2288. Chattarji, P. P., Torsion of curved beams of rectangular cross-section having transverse isotropy (in English), *ZAMM* **38,** 3/4, 157–159, Mar./Apr. 1958.

Extension of Langhaar's solution [AMR **5** (1952), Rev. 383] to transversely isotropic case. S. C. Das, India

2289. Lin, T.-C., On the Saint-Venant flexure problem for cross sections of a series of symmetrical airfoils (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **6,** 187–197.

Author presents a further elaboration of Stevenson's reduction of the classical Saint-Venant flexure problem, using complex functions for the usual flexure functions. The method is applied to a series of symmetrical airfoils.

Boundary conditions of the real canonical functions are expressed as either the real or imaginary parts of functions of a complex variable. Singularities result inside the cross section and these are eliminated in this method. An exact general solution is found giving displacements, stresses, torsional rigidity and coordinates of the center of twist. The solution for the lemniscae obtained by Bernoulli is compared with that by Stevenson's method and the alteration of shearing stress distribution with thinning airfoil sections is outlined.

The method appears a useful elaboration of the classical Saint-Venant flexure problem. R. Culver, South Australia

2290. Polasek, J., The center of flexure and the torsional rigidity of the turbine blade (in French), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **6,** 96–100.

An analytic method is briefly presented (presumably as read) for the accurate assessment of the torsion-flexure problem for turbine blade profiles. It is done to compare the errors in approximate experimental and numerical methods.

The blade profile is represented conformally and the necessary boundary conditions set down. Using a series form for the complex stress function, values for the torsion constant are established and Stevenson's equations are used to establish the coordinates of the "centre of flexure."

For symmetrical profiles a brief comparison (without values being stated) is made between the values obtained by author and those from approximate solutions of Griffith and Taylor, and Duncan.

No references are mentioned. Reviewer finds that the method and its use is given far too brief a treatment for a written paper. R. Culver, South Australia

2291. Volov, G. M., Bending and torsion in a rectangular beam, loaded on its lateral surface (in Russian), *Trudĭ Naucb. Konferentsii Stalinskogo Ped. In-ta,* Kemerovsk. Kn. Iz-vo no. 1, 302–307, 1956; *Ref. Zb. Mekb.* no. 7, 1957, Rev. 8159.

The possibility is discussed of solving the problem regarding the deflection and torsion of a rectangular parallelopiped by forces applied to its lateral surface with the help of Fourier's double series; the coefficients in these series should be determined from the infinite systems of linear equations. V. K. Prokopov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Plates, Shells and Membranes

(See also Revs. 2247, 2251, 2267, 2270, 2271, 2273, 2317, 2320, 2322, 2323, 2331, 2333, 2334, 2370, 2372, 2378, 2379, 2401, 2418, 2425, 2545)

2292. Payne, L. E., Inequalities for eigenvalues of supported and free plates, *Quart. Appl. Math.* **16,** 2, 111–120, July 1958.

Bounds for the eigenvalues of the vibration and buckling problems for a supported or a free plate are determined in terms of the eigenvalues of the corresponding fixed or free membrane problems. G. Herrmann, USA

2293. Kulik, A. N., Elastic equilibrium of an elliptical plate with a round opening, reinforced by a thin elastic ring (in Russian), *Dop. Pov. L'vovsk. In-ta* no. 6, part 2, 81–86, 1955; *Ref. Zb. Mekb.* no. 7, 1957, Rev. 8147.

The plane problem is investigated of the stressed condition of an elliptical plate with a round opening, supported by a thin, elastic ring. The center of the ring and the center of symmetry of the ellipse coincide. A hydrostatic pressure of intensity p is applied to the outer outline of the plate. Functions $\varphi(z)$ and $\psi(z)$ are sought by using the method of the theory of functions of complex variables, which characterize the stressed condition, in the form of series' sections. A. Ya. Gorgidze

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2294. Nowacki, W., and Kaliski, S., Some problems of structural analysis of plates with mixed boundary conditions (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **6,** 423–429.

Authors consider a very general problem of a thin plate of an arbitrary shape, loaded arbitrarily by a distributed external load and partly built in (elastically clamped) and elastically supported along segments of the boundary, simply supported or free along the remaining segments. The formal solution of the problem is represented by a system of Fredholm integral equations of the second kind which reduce to equations of the first kind in the case of fully built in segments. Solution can be generalized to cases with mixed boundary conditions along segments located inside the region of the plate, of the combined case, and for the statically indeterminate cases of a plate, supported in any way along the boundary, with additional supports over inner regions of the plate.

A numerical example, if included, would add much to the analysis of the problem, and could show the amount of computations involved in obtaining such a solution.

Z. Karni, Israel

2295. Muller, L. S., Restraint of slabs by edge-beams, *Concr. Const. Engng.* **53,** 7, 251–263, July 1958.

Restraint by marginal beams in slabs spanning in one direction is approximately determined using the following simplifying assumptions: Columns are rigid with respect to bending; edge beams are continuous under several spans; internal supports of the slabs are assumed to be free supports. Under these assumptions it is possible to derive the differential equation of the twist of the edge beam. The differential equation is an homogeneous equation of the second order when the conditions at the edges of the slab are symmetrical or when one of the ends is not elastically supported. Due to the assumed symmetry, the two constants of integration reduce to one. If the conditions at the elastically supported edges are different, the equation is of fourth order; and also due to the symmetry the constants of integration reduce to two. Nomograms and graphics in function of dimensionless variables are given for the different factors appearing in the solutions of the differential equations. An approximative method is also given for computing

the influence of the bending in the columns. Several numerical examples are given. C. A. Sciammarella, USA

2296. Seika, M., The stresses in an elliptic ring under concentrated loading (in English), *ZAMM* **38,** 3/4, 99–105, Mar./Apr. 1958.

An elliptic ring bounded by two confocal ellipses with compressive forces applied at both ends of the axis is considered. The method of solution is due to Muskhelishvili. Numerical results for the elliptic plate and elliptic ring are given.

Z. Olesiak, Poland

2297. Hashin, Z., Analysis of a rectangular plate stiffened by beams along two edges (in French), Cahiers de la Recherche Theorique et Experimentele sur les Materiaux et les Structures, Assn. Fr. Recherches et d'Essais sur let Materiaux et les constructions, Cahier no. 7, 141 pp., 1958.

Author treats bending of rectangular plate, two opposite edges simply supported, other two stiffened by beams. Linearized differential equations include effect of membrane stresses. Limiting conditions along stiffening beams are studied and solutions given for distributed, line and concentrated loads. Experiments are performed which show good agreement with theory.

C. N. DeSilva, USA

2298. Hashin, Z., The stress analysis of a prismatic structure (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **6,** 67–68.

Author outlines method of analysis for a channel-section prismatic structure subjected to symmetrical lateral loading. Structure is considered as a plate supported along parallel edges by elastic beams. Bending moments and shearing forces in the plate are expressed as an infinite series in terms of vertical deflection; membrane forces by an Airy stress function in the form of an infinite series. Constants of the series are determined from the plate boundary conditions. Method gives results considerably different from those obtained with conventional elementary beam theory for width-length ratios greater than 1/4. S. Goodman, USA

2299. Hausrath, A. H., Small deflections of elastically supported plates (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **6,** 367–377.

General solutions of boundary-value problems of clamped or free thin elastic plates on elastic foundation are presented. Method of Bergman, involving construction of a Green's function, enables relationship to be established between deflections of each problem. General development is made through application of complex variable techniques. Conditions are outlined which tell when computation of Green and Neumann functions which yield direct solutions can be avoided, and steps are listed for evaluation of required kernel function. A. W. Coutris, USA

2300. Galletly, G. D., On particular integrals for toroidal shells subjected to uniform internal pressure, *J. Appl. Mech.* **25,** 3, 412–413 (Notes), Sept. 1958.

Two common approximations are used to evaluate a particular integral of the differential equation for toroidal shells which do not include the apex $\phi = 0$. Both methods are compared with the numerical solution of the differential equation for an example.

M. Hampl, Czechoslovakia

2301. Galletly, G. D., A comparison of methods for analyzing bending effects in toroidal shells, *J. Appl. Mech.* **25,** 3, 413–414 (Notes), Sept. 1958.

Three methods used to analyze the bending effects in toroidal shells are briefly described: (a) numerical integration of the differential equations on an electronic digital computer, (b) asymptotic integration method of Clark, and (c) Geckeler-type solution. Edge influence coefficients obtained by these methods for a numerical example are compared.

It is a pity that there is not any general comparison of these methods. M. Hampl, Czechoslovakia

2302. Cohen, M. J., Stress and strain in spinning paraboloid dishes, ASME Semiann. Meet., Detroit, Mich., June 1958. Pap. 58-SA-8, 8 pp.

Author claims to make solution of title problem (important in mirrors used as gyroscope rotors) "a matter of simple arithmetic." A number of functions have been calculated and tabulated to this end.

In the reviewer's opinion the mathematical formulation contains such basic errors that the subsequent analysis and arithmetic—themselves not free from error—are invalidated. Only one basic error need be mentioned. The author uses a compatibility equation between radial and tangential strains which, although true for the limiting case of a flat disk, does not exist for the general surface of revolution unless the latter be constrained against normal deflections. It is therefore surprising that in the numerical case quoted by the author the normal deflection appears to the reviewer to be two orders of magnitude too high.

P. C. Dunne, Brazil

2303. Nash, W. A., and Sheng, P. L., An iteration method for solving linear problems in the theory of shallow shells, *J. Aero. Sci.* **25,** 4, p. 267, Apr. 1958.

A shallow shell is one for which the ratio of its height to a representative base dimension is less than $\frac{1}{8}$. If the equation of the mid-surface can be expressed in dimensionless form as a function of its coordinates, an iteration solution of two differential expressions, one for deflection and the other for membrane stress, becomes possible. This method of solution is briefly presented and discussed. J. P. Vidosic, USA

2304. Houghton, D. S., and Chan, A. S. L., Discontinuity stresses at the junction of a pressurised spherical shell and a cylinder, *Coll. Aero. Cranfield Rep.* 80, 16 pp. + 7 figs., Jan. 1958.

Paper analyzes five cases of pressurized sphere on cylindrical support. Dead weight of structure is not included. Cases are cylinder terminating at sphere and cylinder penetrating sphere, considered with and without axial temperature gradient in the cylinder. Effect of heavy joint ring is also examined. All results appear to be straightforward applications of well-known shell theory with no critical discussion. C. E. Turner, England

2305. Oravas, G.-A., Transverse bending of thin shallow shells of translation (in English), *Öst. Ing-Arch.* **11,** 4, 264–276, Dec. 1957.

Using a simple complex function, author reduces the system of two fundamental equations of the problem to one, which under certain assumptions and limitations gives relatively very simple expressions for stress and displacement functions. As to boundary conditions, stress couples, edge displacements and rotations are considered. In the conclusion a practical example of a thin concrete shell with outlined solution is introduced.

V. Kopriva, Czechoslovakia

2306. Vyrbanov, Kh. P., Integration of systems of linear differential equations in the theory of prismatic and slightly pyramidal shells of V. Z. Vlasov (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 6, 64–76, June 1957.

Using some concepts from works of A. N. Krylov, author proposes a method of solving a system of linear differential equations by representing the unknown functions (each of them) in terms of the sum of two functions. One of them (call it the auxiliary function) is chosen so that it satisfies all the initial or boundary con-

ditions and all the admissible conditions connected with the requirements of the appropriate magnitudes of the coefficients. The second functions in the sums are then determined from the differential equations containing the derivatives of the auxiliary functions. All the functions are represented by means of the trigonometric series. In the next step the differential equations are transformed into difference equations and these associated with the symmetric matrices.

The method is applied to the theory of prismatic and slightly pyramidal shells of V. Z. Vlasov. The way is shown on how to choose the proper intervals of the unknown functions in order to obtain the required degree of accuracy. There is no formal proof presented of the existence or of the uniqueness of the procedure. Author proposes only the method of constructing the solution. Using this technique he demonstrates that in all the discussed cases the systems in question always possess solutions satisfying the required initial or boundary conditions with the desired degree of precision. M. Z. v.Krzywoblocki, USA

2307. Crandall, S. H., and Dahl, N. C., The influence of pressure on the bending of curved tubes (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **6**, 101–111.

Problem considered is the effect of internal pressure and in-plane bending on the stresses and flexibility of long-radius pipe bends. Authors start with E. Reissner's equations for the finite deflections of thin shells and, making various approximations, they derive two linear coupled ordinary differential equations in which the pressure effects are included. Their series solution of these equations is in fairly good agreement with available experimental data.

Authors also derive an asymptotic solution to the equations valid for large values of a geometric parameter μ. Since their series and asymptotic solutions do not merge smoothly, authors conclude that more terms are required in their series solution.

G. D. Galletly, USA

2308. Rzhanitsyn, A. R., The design of plates and shells by the kinematical method of limit equilibrium (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **6**, 331–343.

The kinematic method of plasticity is further developed and applied to the design of thin plates and shells, loaded by axial forces and bending moments. If the displacements of the system linearly depend on the parameters, the differential quotient of the work of internal forces to the parameters of displacement may be replaced by the quotient of the values themselves. In thin plates and shells the author takes, instead of distributed deformations, concentrated ones along lines. It is possible to find the position of the line of concentrated deformations from the condition of the minimum load, which is equivalent to a corresponding variation problem. Some examples of the solutions are given.

L. Foppl, Germany

2309. Schwalbe, W. L., Conjugate load method for a thin shell with extensional behavior only (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **6**, 344–350.

Extension of previous analyses by author [see e.g. AMR **7** (1954), Rev. 2790 and *J. Roy. Aero. Soc.* p. 199, Mar. 1955] in which shell is subdivided into two intersecting systems of mutually perpendicular members. Lateral load is similarly divided between the two systems so that the behavior of a single member is the same as the member considered as an integral part of the shell. Applications and advantages of method are not stated.

G. P. Fisher, USA

2310. Gubanova, U. I., Rotation of a curvilinear elastic rod in an undeformed curvilinear shell (in Russian), *Izv. Akad. Nauk LatvSSR* no. 10, 127–140, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8300.

The behavior is examined of an elastic curvilinear rod in an undeformed flexible shell, under the influence of a torsion moment applied to one of the ends. The rod is placed in the shell without any clearance. The curvature of the axial line is taken to be constant along the length of the rod, the section of which is small by comparison with the radius of curvature of the axis. When investigating the motion of the rod neither the friction forces nor the inertia forces are taken into account. Expressions are deduced for the deformations due to shear and tension (compression), the normal and tangential stresses are determined, and also the amplitude of the internal forces in any section of the rod. Account is taken of the initial stresses appearing when laying the initially bent rod in the shell with another radius of curvature. A differential equation for the problem was obtained, which integrated in elliptical functions. The nonlinear relation is established between the angles of rotation and, in consequence, between the angular velocities of the ends of the rod. The relations are given for the change of resistance of the rod to rotation in functions of the angle of rotation of the terminal section. It is noted that the initial curve of the core of the flexible roller in the absence of the interlayer clearances leads to the discordance in the value of the angular velocities of the roller ends. In the presence of interlayer clearances the initial curve of the core contributes significantly to the increase of tangential stresses. The apparatus is described which was created for the purpose of checking the theoretical deductions. The experimental results compare favorably with the calculation curves. Yu. P. Grigor'ev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2311. Nikol'skii, E. N., Strains and stresses in cylindrical shells and thin-walled bars with undeformable cross sections (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 6, 45–54, June 1956.

Author states that if a structure described in title is designed on the basis of the elementary bending theory, it is often necessary to examine the state of stress in the neighborhood of the points of attachment of the external forces. To this problem he devotes the present paper, taking the shear strain into consideration. Differential and integral equations of the problem are given together with the boundary conditions. Solution is obtained by means of trigonometric series. The general solution is represented as a sum of the solution of the plane problem of a rectangular plate and the problem of shell loaded by surface forces with zero edge conditions. A diagram shows the experimental and calculation results for a cantilever shell with cross section in the form of a semicircle 16.4 cm in diameter, 202 cm in length, and 0.195 cm in thickness. From this diagram it follows that the measured stresses are in good agreement with the stresses calculated according to the method described.

W. Wierzbicki, Poland

Buckling

(See also Revs. 2267, 2268)

2312. Stabilini, L., Instability problems of steel structures (in German), *Bauingenieur* **33**, 6, 213–220, June 1958.

Paper deals with a lecture on the present state of knowledge on the theory of stability, presented at the Technical University in Berlin-Charlottenburg on the 5th of July, 1956. Referring to beams, three groups of problems have to be discerned: the case of elastic stability, of aerodynamic instability and the case of impossibility of equilibrium. The first occurs when, during the increase of loading force, the elastic body, owing to its deformation, changes from the stable position through the indifferent to unstable equilibrium. This is characterized by the point of divergence.

The phenomenon of aerodynamic instability is not a property of the beam but of the medium (air, water) in which the beam is placed. This plays a special part in case of suspension bridges and its explanation is attempted by three different theories: by the theory of negative slope, of slip-stream and by the theory of floating wing. The third group deals with different phenomena without a point of divergence: deformation increasing faster than loading, primary deformation followed by secondary, and instability cases of rigid bodies. Classification is followed by detailed description of elastic stability problems and their methods of solution.

Literature giving fundamental solutions is systematized with ample Italian references. I. Korányi, Hungary

2313. Angervo, K., On the buckling and the bearing capacity of an eccentrically compressed column without tensile strength below and above the proportional limit, with particular consideration of rectangular cross section (in German), State Inst. Tech. Res., Finland Publication 26, 61 pp. + 5 appendices, 1954.

Title problem for linear elastic and a two-parameter family of nonlinear materials is discussed. No reference is made to related work of Karman, Chwalla, Ježek and others. Results are presented in the form of curves, although inaccurate definition of symbols impairs clarity. K. S. Pister, USA

2314. Mason, R. E., Fisher, G. P., and Winter, G., Eccentrically-loaded, hinged steel columns, *Proc. Amer. Soc. Civ. Engrs.* **84,** EM 4 (*J. Engng. Mech. Div.*), Pap. 1792, 19 pp., Oct. 1958.

2315. Campus, F., and Massonnet, C., Buckling of ST 37 steel double tee section columns, submitted to oblique compression forces (in Portugese), Intern. Assoc. Bridge and Structural Engng., Report of the 5th Congres, Liège, Report IV c 3, 19 pp., 1957.

2316. Umanskii, E. S., An approximate method for determining Euler's load (in Russian), *Izv. Kievsk. Politekhn. Inta* **19,** 303–315, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8332.

The approximate method of solution of differential equations proposed by Yu. D. Sokolov is applied to the problem of the stability of the plane form of deflection of beams of rectangular section of constant and variable rigidity. In the second term of the differential equation for determining the angle of twist

$$B_1 C \frac{d^2\beta}{dz^2} + M_x \beta = 0 \qquad [1]$$

function β is taken to be equal to the constant value α_1. Constant α_1 is determined as the mean value in the range from 0 to l (l is the length of the beam) of the approximate function β_1 found from the equation

$$\frac{d^2\beta_1}{dz^2} = -\frac{M_x \alpha_1}{B_1 C} \qquad [2]$$

The critical load, entering into the expression of the deflection moment M_x, is found from the solution of equation [2]; to do so the found value of α_1 is introduced into this solution and use is made also of the condition of the fastened beam. In order to obtain subsequent approximations, function β in the second term of equation [1] is taken to be equal to $\beta_{n-1} + \alpha_n$, where the constant α_n is equal to the mean value of function $\beta_n - \beta_{n-1}$ in the range (0, 1). The approximate values of the critical loads, obtained for a number of particular cases, are compared with precise solutions; there was a divergence up to 13.5% in the first approximation and up to 3.5% in the second. V. F. Lukovnikov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2317. Seide, P., Compressive buckling of a long simply supported plate on an elastic foundation, *J. Aero. Sci.* **25,** 6, 382–384, June 1958.

An infinitely long flat plate, simply supported at its long edges and compressed in the longitudinal direction along x-axis, is considered. The plate rests on, but is not attached to, a foundation of the Winkler type. The plate is expected to buckle in some repetitive pattern so that one part of the pattern compresses the foundation while the remaining portion separates from the foundation. The problem is then reduced to the simultaneous solution of the differential equations governing the deflections of these two regions connected by the boundary conditions of zero deflection and continuity of slope, moment and shear. In addition, the deflections of each region are symmetrical with respect to the center lines. By assuming deflection functions of the form

$$w_1 = F_1(x_1)\cos(\pi y/b) \qquad w_2 = F_2(x_2)\cos(\pi y/b)$$

and by substituting these functions into the differential equations and boundary conditions a transcendental equation of stability criterion is obtained. For a given value of the foundation modulus parameter a process of trial and error finally leads to the solution of a minimum value of the buckling load coefficient. The numerical calculations indicate that the lack of attachment of the plate to the foundation results in a drastic reduction in the buckling load coefficient, from a value limited only by the inelastic properties of the plate material to a maximum possible value of 16/3, or only 33% increase above that for the plate without a foundation.

Reviewer objects to the use of the symbols x and y in Eqs. [11] to refer to quantities different from those defined in the symbol list. This, however, is a very minor point and does not affect the value of this paper. G. C. K. Yeh, USA

2318. Ebel, H., The buckling of cylinders under axial loads according to nonlinear stability theory (in German), *Stahlbau* **27,** 2, 45–53, Feb. 1958.

This is a lecture delivered for Prof. K. Klöppel's group at Darmstadt. Section 1 contains the results of the classical theory of the problem according to Lorenz, Timoshenko and Flügge. In section 2 foundations of the nonlinear theory of the problem are given where the first derivative of the deflection in the principal differential equation of the problem is not assumed to be zero. Section 3 is devoted to the application of the Ritz method to the solution of the problem. Section 4 presents computations according to von Karman and Tsien, while section 5 contains computations according to J. Kempner who introduces an additional coefficient in the Ritz method. This circumstance makes the solution more difficult; therefore a computing device was used. Finally, section 6 contains a discussion of buckling in the plastic region. The results are discussed and represented by means of diagrams. W. Wierzbicki, Poland

2319. Gerard, G., Plastic stability theory of thin shells under external pressure (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **6,** 225–234.

Equations for the plastic buckling of thin shells of constant unequal radii (cylinders, spheres, circular translational shells, plates) are derived on the basis of deformation theory and small deflections. These equations can be reduced to a Donnell-type single equation in particular cases, and are solved for the case of the sphere and of cylinders of moderate length, obtaining results equivalent to those of Bijlaard.

M. G. Salvadori, USA

2320. Chien, W.-Z., and Hu, H.-C., On the snapping of a thin spherical cap (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **6,** 309–320.

Two distinct buckling problems are treated. The first concerns the snapping of a thin shallow spherical cap subject to a uniform

line load distributed in an axisymmetric manner about a circle of arbitrary radius. Conditions of simple support are assumed around the edge of the spherical cap. The governing nonlinear equations are solved by an energy method to obtain the load-deflection relations. These are not in good agreement with experimental evidence and the values of the parameters determined by the energy technique are modified on the basis of experimental evidence so as to provide a semi-empirical result. The second problem is concerned with the snapping of a thin shallow spherical cap subject to an axisymmetric bending moment distributed uniformly around the edge. The nonlinear equations are solved approximately by decomposing the problem into two nearly equivalent linear problems and solving each of these.

W. A. Nash, USA

2321. Boguslavskii, A. N., The approximate calculation of the coefficients of form stability (in Russian), *Sudostroenie* no. 6, 1-4, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4325.

2322. Nazarov, O. O., Large deflections and stability (strength) of a hollow shell of double curvature with rigidly fastened edges (in Russian), *Dop. Akad. Nauk URSR* no. 3, 231-234, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8170.

Large deflections are investigated of a hollow shell of double curvature, rectangular in plane, when under the action of an evenly distributed transverse load. The edges of the panel are assumed to be fastened and incapable of displacement. In the first approximation the author takes for the deflection the expression

$$w = C\left(1 + \cos\frac{2\pi x}{a}\right)\left(1 + \cos\frac{2\pi y}{b}\right)$$

where a and b are the sides of the panel. Making use of the equation of the joint deformation, author determines the stress function and, further, utilizes the Bubnov method (recalling the work of S. P. Timoshenko: "The strength (stability) of elastic systems," *Sbornik In-ta Inzh. Put. Soobshch.* no. 31, 1913). In the result a relation is obtained between the maximum deflection w_0 and the load parameter P in the form of

$$B_3\left(\frac{w_0}{b}\right)^3 - \left(\frac{\delta}{b}\right)B_2\left(\frac{w_0}{b}\right)^2 + \left[\left(\frac{\delta}{b}\right)^2 B_1 + B_0\right]\left(\frac{w_0}{b}\right) = P$$

δ is the line of lift of the panel, b the thickness. A table is furnished for the upper critical load. It is known that the first approximation results in significant error when determining the critical points.

A. S. Vol'mir

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2323. Grigolyuk, E. I., Calculation for stability of bimetallic cylindrical shells (in Russian), *Inzhener. Sb.* **23**, 28-35, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8174.

Applying the energy method, author gives the solution of the problem of the elastic stability (strength) of bimetallic cylindrical shells under the joint action of a uniform axial and radial pressure. Assuming that Poisson's ratios for the layers are the same, and also the hypothesis of undeforming norms, author obtains an equation for the determination of the critical combinations of axial and radial pressures. The equation obtained appears to be a generalization of known formulas used to determine critical loads in the case of homogeneous shells. A case is investigated in detail of uniform pressure on various cylindrical shells in different ratios of the moduli of elasticity to the thicknesses of the layers. Detailed tables are constructed for the values of critical pressures and the corresponding surrounding waves.

S. A. Ambartsumyan

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Vibrations of Solids

(See also Revs. 2283, 2388, 2412, 2413, 2414, 2415, 2423, 2683, 2685, 2722)

Book—2324. Schuler, M., Mechanical vibrations, Part I: Simple vibrations [Mechanische Schwingungslehre, Teil I: Einfache Schwinger], 2nd revised ed., Leipzig, Akademische Verlagsgesellschaft, 1958, viii + 158 pp. DM15.

Book is the text of a course of university lectures given by the author between the years 1929 and 1946. This first part treats single degree of freedom only, except that there is some discussion of the spherical pendulum.

The orthodox treatment of free and forced motion is thoroughly dealt with, but the particular interest of the book is its discussion of the effects of small departures from linearity. This discussion is mainly concerned with the time-keeping abilities of clocks and includes, for instance, a section on the effect of a noncircular knife-edge profile. Author has had considerable experience in the design of high-precision clocks.

The book is illustrated by clear diagrams and the graphical presentation of mathematical theory is very pleasing. Those concerned with vibration theory will value this book for the light which it sheds on the lesser-known fringes of a well-worn road.

D. C. Johnson, England

Book—2325. Burton, R., Vibration and impact, Reading, Mass., Addison-Wesley Publishing Co., Inc., 1958, x + 310 pp. $8.50.

A text designed (according to author) for senior and introductory graduate courses. Extremely broad in scope it covers subject matter not usually found in texts on vibration. Chapters on wave propagation, control systems analysis, and fatigue are included along with the expected treatment of vibrating systems of one and two degrees of freedom. Brief treatments of nonlinear vibrations, random excitation, beam and plate vibrations, and several approximate methods for computing normal modes of n degree-of-freedom systems are included.

Reviewer believes the book to be an excellent one for author's announced purpose; viz, to provide introduction and physical significance to the broad field of study. It lacks, as may be expected, the depth of treatment required for specialized study at graduate level.

W. C. Hurty, USA

Book—2326. Brennan, J. N., (editor), Bibliography on shock and shock excited vibrations. Vol. I, Pennsylvania State University, College of Engineering and Architecture, Engng. Res. Bull. no. 68, vi + 348 pp. Sept. 1957. $2 (Paperbound)

Bibliography consists of three parts. The main body of the text consists of an introduction and abstracts of 1168 technical papers on subjects related to shock motion and its measurement. This is followed by Part II, which consists of six summaries of abstracts related to subdivisions of the field: Dynamic behavior of materials under impulsive loads; Dynamic behavior of structures under impulsive loads; Impact testing devices; Instrumentation for measuring impulsive forces and motions; The shock spectrum approach to impact problems; Mathematical methods for investigating dynamic behavior of structures under impulsive loading. The final part consists of an appendix that includes an author index, a subject index and the details of the scope of the search that resulted in these abstracts.

The abstracts are mainly of papers that have been published in technical journals and of patents. A few government reports are also included. Originally it was planned to include abstracts of all pertinent government documents in this publication. However, it now appears desirable to publish these separately in a subsequen volume, due to the bulk of the material involved and the necessary time that will be required to process it.

From author's summary

2327. Branson, C. F., Static friction in dynamic systems, *J. Aero/Space Sci.* **25,** 10, 654–655 (Reader's Forum), Oct. 1958.

The note studies the effect of speed-dependent Coulomb friction on a simple two-degree-of-freedom system and finds that the sign of the damping is dependent upon the sign combinations of the coupling terms. M. G. Scherberg, USA

2328. Archibald, F. R., and Emslie, A. G., The vibration of a string having a uniform motion along its length, *J. Appl. Mech.* **25,** 3, 347–348, Sept. 1958.

Frequencies of free, small vibrations of uniformly moving string are calculated. Using Hamilton's principle, authors derive basic differential equation which indicates presence of centrifugal and Coriolis forces on an element of string. Application to high-speed power chain or belt is discussed, with indications of resonance possibilities. Belt over two pulleys, one eccentrically mounted, is treated as an example of forced vibrations. Reviewer notes misprint in Eq. [8]. T. P. Mitchell, USA

2329. Cox, H. L., Vibration of axially loaded beams carrying distributed masses, *J. Acoust. Soc. Amer.* **30,** 6, 568–571, June 1958.

The lowest two natural frequencies of flexural vibration are obtained by the use of energy methods for uniform axially loaded beams which rest on elastic foundations and which carry masses that may be distributed symmetrically along portions of the spans of the beams. The ends of the beams may be either pinned or clamped. Simple formulas for the lowest two frequencies are given so that one may compute rapidly a desired frequency and determine the effects of the various parameters which influence that frequency.

From author's summary by J. C. Wilhoit, Jr., USA

2330. Bronskii, A. P., Determination of natural frequencies in transverse vibrations of beams carrying concentrated loads (in Russian), *Ucb. Zap. Mosk. Gor. Ped. In-ta* **49,** 135–138, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8207.

Integration of the equations of transverse vibrations of the beam is carried out by the customary method of separating the variables. The frequency equation is recorded for three special cases, and for two cases (a concentrated mass at the end and in the center of the beam) an approximate value is given for the first two roots. I. S. Arzhanykh

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2331. Sakharov, I. E., Natural frequencies of ring-shaped plates (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 5, 108–110, May 1957.

The natural frequencies of vibration of a ring-shaped plate are calculated for the cases of the inner edge free of shear and moments, and the outer edge either clamped or simply supported. The method used is straightforward and consists in evaluating the determinantal equation obtained from the solution of the differential equation and application of the boundary conditions. The details of the evaluation are not given. The results for zero, one and two nodal diameters are shown graphically for various ratios of inner to outer radius. A modified formula is given which the author states can be used for the natural frequencies of a ring-shaped shell. E. Saibel, USA

2332. Bespalova, L. V., On the theory of vibrating impact mechanism (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 5, 3–14, May 1957.

Behavior of a vibrating system with one degree of freedom, idealizing a vibrating impact mechanism, is studied in detail.

The supplementary system consists of a mass suspended on a linear spring, acted upon by periodic harmonic force. The motion of the mass is assumed to be constrained by a semielastic plane, elastic properties of which may be characterized by a certain coefficient of restitution. Author investigates all possible periodic motions of this system, together with corresponding conditions of stability. At the same time a special case of the system without spring is taken under consideration.

Author describes an electric circuit with seven amplifying-units, which allows the analog solution of the problem dealt with.

Paper is well written and easy to follow. By including a detailed investigation of the impact intensity in different cases the importance of the paper, in my opinion, would be extended.

K. Julis, Czechoslovakia

2333. Bolotin, V. V., End deformations of flexible pipe conduits (in Russian), *Trudi Mosk. Energ. In-ta* no. 19, 272–291, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8425.

The problem of large deflections of a straight flexible pipe conduit containing a rapidly moving liquid is examined. Such a pipe conduit can become unstable. An analysis is also given of the movement and of the conditions of equilibrium for the pipe conduit on the assumption that the deflections are small. The case is examined of a hinge fastening in the presence of an axial force and linear damping during transverse vibrations. Then nonlinear vibrations are investigated. The nonlinearity is conditioned by a longitudinal elastic bond and an inertia force of the attached mass acting on the longitudinal transposition. A determination is made of the deflection relation in terms of the function of flow velocity. Finally, the case is examined of a discontinuous longitudinal elastic bond. V. I. Feodos'ev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2334. Reissner, E., Contributions to the theory of thin elastic shells (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **6,** 290–296.

Differential equations of linearized small-deflection theory of thin shells are derived for general case of orthogonal coordinates other than lines-of-curvature coordinates. In line with assumptions it is noted that one of the six equilibrium equations is to be disregarded in order to have a complete and consistent system of differential equations.

Upper and lower bounds of flexibility constants (influence coefficients) for rotationally symmetric deformations of a linearly elastic circular cylindrical shell of variable wall thickness—one edge free and other edge acted upon by moments and radial forces—are determined by application of minimum principles. Several such coefficients are bounded simultaneously. Extension of author's work to other problems for beams, plates, and shells in which arrays of influence coefficients occur will be seen to be possible.

Results obtained for bending vibrations of shallow linearly elastic spherical shells without axial symmetry are reported. Plate theory, membrane theory of shells, and theory of inextensional deformations of shells are included as special limiting cases. Problem of frequencies of free vibrations of shell segment is treated. A. W. Coutris, USA

Wave Motion and Impact in Solids

(See also Revs. 2198, 2325, 2326, 2328, 2332, 2346, 2370, 2375, 2410, 2411, 2414, 2416, 2695, 2718, 2719, 2720, 2721)

2335. Durelli, A. J., Dally, J. W., and Riley, W. F., Stress concentration factors under dynamic loading conditions, AFOSR TN 58-892 (Armour Res. Found., Ill. Inst. Technol.; ASTIA AD 204 137), 12 pp. + 11 figs., Dec. 1958.

Dynamic photoelastic methods with a low modulus urethane rubber as the model material were employed to study stress concentrations resulting from geometric discontinuities in rectangular bars subjected to an axial impact. The impact was applied by dropping a weight on one end of the bar, and the dynamic fringe patterns were photographed with both a Fastax camera and a microflash still camera combination.

The results of the investigation show that the maximum stress in a rectangular bar with a central circular hole occurs at the same minimum section for static or dynamic loading, and the stress concentration factors are the same. Whether the coincidence of the static and dynamic stress concentration factors is a general law remains to be established.

It was also established in the investigation that the average velocity of fringe propagation through the region of the discontinuity is the same as the velocity of fringe propagation in a region of the bar far removed from the discontinuity. Thus, a fringe reaches a point after the discontinuity at the precise time it would have reached the point had the discontinuity not been present. From authors' summary

2336. Synge, J. L., Flux of energy for elastic waves in anisotropic media, *Proc. Roy. Irish Acad.* (*A*) **58,** 2, 13–21, Nov. 1958.

Paper supplements earlier work [AMR **9** (1956), Rev. 3521]. An energy-flux expression F_p is obtained for simple harmonic vibrations. F_p is specialized for system of plane waves. For real values of Cartesian coordinates y_p, it is shown that the energy-flux vector F_p is directed along the normal to the "slowness surface" at point y_p, where the slowness surface S is defined by an equation $\Omega(y) = 0$. The sign of energy flux F_p, expressed as a function of position on S, is characterized in terms of three sheets S_1, S_2, S_3 into which S is cut by any straight ray R (given all directions). The general results are specialized for waves in an infinite horizontal slab of anisotropic material, the upper face being free and the lower face being subjected to travelling waves of stress. Six systems of plane waves are set up in the slab. For applied stress waves travelling with infinite speed, the planes of all six waves are horizontal, three planes travel up, carrying energy up and three planes travel down, carrying energy down. For applied stress waves of finite speed, the six planes become oblique. A plane may change its direction of travel (up or down), but still three travel up and three travel down. As the speed of the applied stress wave is reduced, the six waves which correspond to the six roots of a sextic characteristic equation coalesce in pairs and become complex. To each complex pair there corresponds two energy fluxes, now both horizontal (instead of up and down) and parallel to one another. For an infinitely thick slab, the system reduces to three horizontal energy fluxes.
A. P. Boresi, USA

2337. Folk, R., Fox, G., Shook, C. A., and Curtis, C. W., Elastic strain produced by sudden application of pressure to one end of a cylindrical bar. I. Theory, *J. Acoust. Soc. Amer.* **30,** 6, 552–558, June 1958.

Authors present the formal mathematical solution to the problem of a semi-infinite rod, subjected to a step axial pressure on its radially constrained end, in accord with the equations of motion of linear elasticity. The solution for the strain (sum of axial and hoop) is obtained through the use of multi-integral transforms (infinite Fourier sine, cosine and exponential), inversion being accomplished through residue theory. The solution is composed of an infinite series of Fourier integrals, the arguments of which depend on the roots of the Pochhammer frequency equation. The complexity of these integrals permit only limited numerical evaluation, which is obtained through large distance approximations and the saddle-point method of integration.

This technique leads to an approximate solution for the strain in infinite series form, evaluation of which can be accomplished through numerical information on the roots of the Pochhammer frequency equation and associated amplitudes. Information of this type is given by the authors for the lowest two modes of the frequency equation.

In addition, authors show that the approximation to the strain, for large distances in the vicinity of the bar velocity arrival time (lowest mode, long wave approximation), is given by an integral of the Airy function. The same result was found recently by Skalak [AMR **10**,(1957), Rev. 3555] for the related longitudinal impact problem.

Reviewer believes authors' work is a significant contribution, particularly in that the method of solution presented is applicable more generally to other end conditions of the mixed type (specification of a displacement and stress). On the other hand, unfortunately it apparently is not a technique that will yield an exact solution to the basic unsolved pressure-shock problem (non-mixed type). J. Miklowitz, USA

2338. Fox, G., and Curtis, C. W., Elastic strain produced by sudden application of pressure to one end of a cylindrical bar. II. Experimental observations, *J. Acoust. Soc. Amer.* **30,** 6, 559–563, June 1958.

In the experimental part of this investigation (see previous review for theoretical part I) authors used an aerodynamic shock-tube excitation of a long magnesium rod, and measured surface strain response at stations remote from the source with the aid of barium titanate gages. The conditions at the source end are a step pressure and no shear stress; hence the experiment is the analog of the analytical pressure shock problem.

The asymptotic approximations given in part I were found to be in good agreement with the experimental rod disturbance in spite of the difference in end conditions in the theory and experiment, indicating a large distance independency of the radial constraint at the source end. In addition to the now well-known good agreement exhibited by the early disturbance at a station, governed by the long waves of the lowest Pochhammer mode, good agreement is also found in the subsequent time region for amplitudes (and periods) of the slower traveling moderately short waves of this same mode. The theory and experiment show that for a given velocity this amplitude varies inversely as the square root of the distance traveled. J. Miklowitz, USA

2339. Aleksandrina, N. I., Impact of a weight on a beam (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 4, 85–92, Apr. 1957.

Writer considers the impact of a weight on a beam with the following assumptions: the beam possesses infinitely many degrees of freedom when the local elastoplastic deformations are taken into account; the stress-strain relation is a linear one and the stress-strain curve is approximated by a polygon; the influence of the local stresses during the impact upon the general shape of the deflected beam is disregarded, etc. The impacting weight is considered to be a material point, moving vertically with the velocity vector directed downward in the vertical plane. The problem reduces to a joint solving of the equations of motion of the falling weight and of the elastic system of the beam.
M. Z. v. Krzywoblocki, USA

2340. Volarovich, M. P., and Balashov, D. B., Study of the influence of peripheral pressure up to 1000 kg/cm² on the speed of propagation of elastic waves in samples of coal (in Russian), *Tr. Geofiz. In-ta, Akad. Nauk SSSR* no. 34(161), 164–178, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10918.

The means used and the results obtained from tests on the measurement of speeds of elastic waves in different types of coal at peripheral pressures up to 1000 kg/cm² are described. It is established that the velocity of elastic waves increases with

pressure in accordance with the curvilinear principle. A qualitative explanation is given of the observed effects.

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2341. Babich, V. M., The ray method of calculating the intensivity of wave fronts (in Russian), *Dokladĭ Akad. Nauk SSSR (N.S.)* **110,** 3, 355-357, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8192.

Allowing function $u(x,y,z,t)$ to describe the wave process, and to be presented near the wave front in the following terms, one obtains

$$u = u_0(x,y,z)\, f_0(t-\tau) + u_1(x,y,z)\, f_1(t-\tau) + 0\,(f_2(t-\tau))$$
$$|f_0| >> |f_1| \qquad |f_1| >> |f_2|$$

Author designates the intensity of the wavefront as $|u_0|$ and gives a method of calculating this value for a heterogeneous elastic body. His method is based on the transfer to coordinates of the radii of spreading of the longitudinal and transverse waves (the third coordinate is the time of spreading of the wave process). The calculations are connected with the fundamental ones studied previously by the author in another work. Some energetic concepts are advanced to clarify the ray method. I. S. Arzhanykh

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2342. Arzhanykh, I. S., Some new questions on vector structure of transformation of dynamic problems in the theory of elasticity (in Russian), *Trudĭ In-ta Matem. i Mekhan. Akad. Nauk UzSSR* no. 17, 87-116, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8191.

Results of previous works are published. The transformation vector is determined, satisfying Lame's dynamic equation, through its divergence, vortex and given boundary elements—the transformation vector on the body's surface and its full normal derivative. Structural formulas are obtained for the transformation vector. The integrodifferential and integral equations are examined, which determine the unknown values entering the structural expressions of the transformation vector. The solution of these equations is not given. N. A. Kil'chevskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2343. Varlamov, N. N., Kinematic picture of the impact of a vessel on another body (in Russian), *Trudĭ Leningr. In-ta Inzh. Vod. Transp.* no. 22, 80-88, 1955; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4321.

An examination of two elementary problems of impact: (1) a not completely elastic impact of a body on an immobile rigid surface (the impact of a vessel on an obstruction); (2) a not completely elastic impact of a body on another body at rest (impact of a vessel on a pontoon).

All the calculations are elementary and represent the use of the known theorems of the theory on impact. A. K. Nikitin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2344. Van Name, F. W., Jr., Experiment for measuring the coefficient of restitution, *Amer. J. Phys.* **26,** 6, 386-388, Sept. 1958.

An intermediate mechanics experiment is described in which the coefficient of restitution is determined from measurements on the oblique impact between two spheres. A typical set of data is presented. From author's summary

2345. Thomas, T. Y., Plastic disturbances whose speed of propagation is less than the velocity of a shear wave, *J. Math. Mech.* **7,** 6, 893-900, Nov. 1958.

Paper deals with plastic disturbance in an elastic-perfectly plastic material which is assumed to be totally incompressible and to obey von Mises yield condition. Stress components and velocity components, but not necessarily their spatial derivatives, are assumed to be continuous across the disturbance. The case in which the speed of propagation of the disturbance is numerically less than the velocity of a shear wave is investigated. Application of the analysis to the propagation of a transverse crack in a thin plate under longitudinal tension is given.

L.-W. Hu, USA

Soil Mechanics: Fundamental

(See also Revs. 2284, 2299, 2329, 2591, 2700)

2346. Davin, M., Study of the dynamic behaviour of stratified soils. Parts I and II (in French), *Ann. Ponts Chauss.* **128,**2, 231-271, Mar./Apr. 1958; **128,** 3, 295-314, May/June 1958.

Stratified soils homogeneous in the horizontal plane and heterogeneous vertically are subjected to moving loads to produce a sine variation of load intensity. This loading becomes a source of wave propagation which for certain velocity functions and with the assumptions of isotropy for modulus of elasticity, Poisson's ratio, and celerity yields mathematical expressions for stress and strain. Operational mathematics is used throughout. The method and results have basic value for research in the behavior of subgrades under heavy moving loads. K. N. Hendrickson, USA

2347. Boychenko, P. O., The determination of the plasticity limits of a soil by the cone method (in Russian), *Uch. Zap. LGU* no. 209, 121-143, 1956; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3533.

A method is suggested for determining the limits of plasticity of soils by the cone test, in place of the method of A. M. Vassiliev for the laboratory determination of plasticity limits, recommended by GOST specification 5184-49, as well as the method of laboratory determination of the limit of roll, recommended in GOST 5183-49.

In the new method, the cone has a weight of 300g and an apex angle of 30°. The internal diameter of the ring containing the sample of soil for determining the plasticity limits is 50 mm. The limit of roll is defined as the degree of humidity of the soil sample at which the depth of penetration of the cone is 4 mm, which corresponds to the results of determination of this limit of plasticity by the usual method for marls and light loams. The limit of flow is defined as the degree of humidity of the soil for a penetration depth of 32 mm, corresponding to its determination on the instrument of V. V. Okhotin for a lift of the cup of 15 cm. The humidity of the soil as determined by A. M. Vassiliev's method, on the other hand, corresponds to a depth of penetration of 22.5 mm.

Numerous experiments are quoted, indicating the high degree of accuracy of determination of the limit of roll by the cone method (expressed in tenths of one per cent humidity), and the limit of flow (about 1% humidity). S. A. Poza

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2348. Romanov, V. V., The problem of the relationship between the capillary and filtration properties of large-pore nonstructural soils (in Russian), *Trudĭ Gos. Gidrolog. In-ta* no. 48, 146-155, 1955; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4493.

An approximation method is given for determining the filtration coefficient K of a soil and the discharge of the capillary flow which rises from the level of the soil water to a height of h. The soil is considered to be a bundle of capillary tubes of differing diameter completely filled by moisture to a height of

$$h = 2\sigma/r\gamma \qquad [1]$$

where r is the radius of a pore referred to the circular section.

The assumptions were made of a homogeneous distribution of pores according to diameters, of the equality of areas of groups of pores of differing diameter, and of the proportionality of the area of the cross section of the pores filled with water at a height h to the moisture at the same height, which leads to a hyperbolic relationship of the moisture distribution according to height in the case of a capillary rise.

It should be noted that the hyperbolic character of the moisture distribution for a capillary rise is not in agreement with the field and laboratory observations [see, for example, A. A. Rode, "Soil moisture," Moscow, Izd-vo Akad. Nauk SSSR, 1952; V. A. Kovda, "Origin and conditions of salt soils," 1, Moscow, Izd-vo Akad. Nauk SSSR, 1946].

Taking the assumptions mentioned into consideration it was shown that from the curve of moisture distribution according to the height $\omega(h)$ in the case of capillary rise and using [1] it is possible to construct a distribution curve of the pores of the soil $\omega(r)$; the measurement of the richness of the soil in pores, the radius of which is less than the given radius r_i, is introduced

$$a_1 = \frac{\Delta \omega_i}{\Delta r_i}$$

and it is recommended that for the characteristic of pore distribution the curve $a(r)$ be constructed.

Using the distribution curve, author suggests that the filtration coefficient K be determined by two methods:

(1) In cases when the soil with an unknown value K has a pore distribution curve which is geometrically similar to the curve for soil with a known filtration coefficient K_1, the relationship K is assumed from the porosity (m) after Kozen, from which it follows that

$$K/K_1 = \left(\frac{m}{m_1}\right)^3 \left(\frac{1-m_1}{1-m}\right)^2 \qquad [2]$$

In this case no account is taken of the fact that, according to Kozen, K depends besides m on the dimension of the particles of the soil (square of effective diameter); therefore equation [2] cannot be considered substantiated.

(2) In cases when the piezometric gradient $I = 1$ and the area of the section of the flow $F = 1$, the value K, numerically equal to the discharge, is calculated as the sum of the flows Q_i passing (independently of one another) through pores of differing radii, while $Q_i = Br_i^2 \Delta \omega_i$, where B = const, $\Delta \omega$ is taken with the curve $\omega(h)$ for various values of h_i, and r_i is determined in accordance with [1].

The value of the capillary discharge at the height h is calculated according to the equation

$$Q_k = \Sigma Q_{ki} \qquad \left(Q_{ki} = Q_i \frac{H_i - h}{h}\right) \qquad [3]$$

where H_i is the maximum height of the capillary rise in pores of a radius r_i.

There is no explanation in the paper of the nature of the motion. The gradient assumed corresponds to the case of a cut of the soil at a height h from the level of the soil waters, while over the plane of the cut the maximum capillary forces expressed by the value H_i are developed. Examples of the calculation are given.

The paper does not make use of the latest non-Soviet works based on similar concepts of the use of the pore distribution curve [N. Collis-George, *Soil Sci.* **76**, 4, 239-250, 1953, et al.].

S. F. Aver'yanov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2349. Vosnessensky, A. S., and Abramov, N. I., A soil hygrometer for determining the humidity, differential porosity, and capillary conductivity of soils (in Russian), *Trudi Gruz. N.-i. In-ta Gidrotekhn. i. Melior.* no. 4/17, 82-90, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6948.

Results are presented of humidity and differential porosity determinations by the value of the water-absorbing force of the soil, measured by strain gages of the Gruz. NIIGiM type, which do not differ from the well-known strain gages of V. G. Korne and others (a porous transmitter in the soil and a vacuum gage recording changes in the humidity of the soil). The instrument permits continuous measurement of soil humidity in the same vertical section of a soil without laborious selection and drying of specimens. At the same time, a qualitative evaluation is given of the mobility of the moisture content by determining the magnitude of the moisture-retaining force. Authors note what is, in their opinion, a decided disadvantage of this instrument in that the range of response is limited and does not embrace the lower humidity values corresponding to a stress above 60 cm Hg. The instrument is recommended for use in fairly moist soils (irrigation, capillary feed, etc.).

O. V. Popov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Fracture (Including Fatigue)

(See also Revs. 2325, 2345, 2373, 2380, 2389, 2392)

2350. Asplund, S. O., The risk of failure, *Struct. Engr.* **36**, 8, 268-270, Aug. 1958.

A review of the whole concept of safety is attempted, summing up the main points of many recent papers. Finally, a general criterion is presented for the rational determination of the risk of failure in a structure. From author's summary

2351. van der Neut, A., Some remarks on the fundamentals of structural safety, *AGARD Rep.* 155, 13 pp. + 4 figs. + 2 appendixes, Nov. 1957.

It is shown that the usual factor of safety is needed almost entirely to account for exceptionally large loads and that only a very small part of it accounts for scatter in strength of aircraft. With present strength requirements comparable load conditions yield inconsistent contributions to the total rate of failure. This results in more structural weight than necessary for the failure rate obtained. Paper advocates establishing the ultimate load as the product of a factor of safety little above unity and the "standard load," which is an exceptionally large load. Nonlinearity being the origin of the inconsistencies mentioned, the suggested concept particularly applies to high-speed aircraft. Paper gives some recommendations for research aiming at the assessment of standard loads and the optimal distribution of the total probability of failure among individual load conditions.

From author's summary

2352. Paul, B., Collapse loads of rings and flanges under uniform twisting moment and radial force, ASME Ann. Meet., New York, N. Y., Nov.-Dec. 1958. Pap. 58-A-55, 6 pp.

Limit loads are found for rigid-plastic rings of arbitrary cross section subjected to uniform twisting moments and radial forces distributed over the circumference. It is shown that the interaction curves for limiting values of twisting moment and radial force have the same shape as interaction curves for limiting bending and stretching of straight beams. For rings of small uniform thickness the collapse loads are found to agree very well with those predicted by thin-plate theory. The theory is applied to find the collapse load of thin-walled corrugated tubes under axial thrust.

From author's summary

2353. Nuchols, J. B., and McGuffey, J. R., Graphitization failures in piping, ASME Ann. Meet., New York, N. Y., Nov.-Dec. 1958. Pap. 58-A-56, 3 pp.

Two major graphitization failures in the high-pressure piping at the Oak Ridge Gaseous Diffusion Plant Power Station indicate the potential hazards for the power industry where comparable piping systems are still operating with carbon-molybdenum steel.

From authors' summary

2354. Starkey, W. L., and Cress, H. A., An analysis of critical stress and mode of failure of a wire rope, ASME Ann. Meet., New York, N. Y., Nov.-Dec. 1958. Pap. 58-A-63, 5 pp.

Many wire-rope manufacturers and machine designers are under the impression that the significant stress in a wire rope is the tensile stress, or possibly the stress due to tension and bending. This paper proves by mathematical analysis that by far the greatest stress in a wire rope results from Hertz contact stresses at points of contact of wire-on-wire, and asserts that the usual mode of failure of a wire rope is fretting-fatigue initiated at such points of contact. Design relationships based on these concepts should be of great value to designers who use wire rope.

From authors' summary

2355. Balaca, A. P., Method for calculating the rupture of reinforced-concrete beams under simple bending (in Spanish), *Cienc. y. Tecn.* **124**, 623, 101-127, Oct. 1957.

Author presents method for calculating rupture of reinforced-concrete beams in bending which takes into account, as important element, the influence of vertical shear. Method is based on concept of principal stresses and on a stress distribution in the concrete which is constant with depth (rectangular). Simple diagrams and tables facilitate the design of such beams. It is brought out that whereas classical theory applied to results of 70 tests estimates strength with a probable error of ± 61 %, proposed method has probable error of only ± 7 %. M. St. Denis, USA

2356. Maringer, R. E., Swetnam, E. B., Marsh, L. L., and Manning, G. K., Study of hydrogen embrittlement of iron by internal-friction methods, *NACA TN* 4328, 27 pp. + 1 table + 35 figs., Sept. 1958.

The effects of electrolytic charging on the properties of relatively pure iron and tempered 4340 steel were investigated metallographically and by observing internal-friction behavior from − 196 to 430 C.

Severe structural damage, consisting of blisters and internal cracks, resulted even after comparatively short charging times. The internal friction of recrystallized iron was particularly sensitive to hydrogen charging. Internal friction of iron and steel below room temperature exhibits phenomena resulting from the interaction of hydrogen atoms and moving dislocations.

From authors' summary

2357. Berry, J. W., Lemaitre, J., and Valluri, S. R., Effect of rest periods on fatigue of high-purity aluminum, *NASA Memo* 11-21-58W, 8 pp. + 3 tables + 8 figs., Dec. 1958.

Tests on aluminum specimens were performed under two conditions. In one the specimens were tested at elevated temperatures and the rest periods were given at room temperature; in the second the specimens were tested at room temperature and the rest periods were given at elevated temperature. The results obtained indicated that the increase of life was negligible in the first condition but that an increase of life may be obtained in the second. In order to check this increase in fatigue life, a second series of tests was carried out on a different lot of specimens and again an increase in life was found. This increase of life appeared to be from 30 to 60% from the average of the results of 20 tests for each test condition. From authors' summary

2358. McEvily, A. J., Jr., and Illg, W., The rate of fatigue-crack propagation in two aluminum alloys, *NACA TN* 4394, 20 pp. + 4 tables + 16 figs., Sept. 1958.

Theoretical considerations indicate primary dependence of crack-propagation rate (r) on the product ($K_N S_{net}$). K_N is the stress concentration factor at the root of the crack and is determined from the crack length, sample width and the endurance limit of the material when it contains a crack. S_{net} is the "true" maximum stress on the specimen during the cycle (maximum load/net remaining area).

A large series of tests on two aluminum alloys (2024-T3 and 7075-T6) are presented. Two-inch and twelve-inch wide sheet specimen are tested in tension fatigue with a large range of maximum stress levels. Initial cracks are made in the center of the samples with impregnated nylon threads.

As a result, an empirical function relating r to $K_N S_{net}$ is established. This seems to fit both alloys and nearly all tests made. It is also shown to check earlier tests by Weibull [AMR **8** (1955), Rev. 2374 and **10** (1957), Rev. 3942].

By comparison with Head's work [AMR **7** (1954), Rev. 2857] the relation is simplified to permit ready estimation of the number of cycles required for a crack to grow from one length to another.

E. G. Chilton, USA

2359. Graham, A., and Walles, K. F. A., Regularities in creep and hot-fatigue data. Part I, *Aero. Res. Counc. Lond. Curr. Pap.* 379, 12 pp. + 4 tables + 9 figs., 1958.

Study of published experimental data of many different materials leads authors to believe that creep strain can be expressed as

$$\epsilon = C_1\sigma^{b_1}t^{k_1} + C_2\sigma^{b_2}t^{k_2} + \ldots.$$

C, b, k are constants, σ = stress, t = time. For constant stress and strain the time-temperature relationship follows: $t(T' - T)^{-A}$ = const. T' and A are constants. Available creep-rupture and hot-fatigue data seem to support the proposed principles.

F. R. Brotzen, USA

2360. Walles, K. F. A., and Graham, A., Regularities in creep and hot-fatigue data. Part II, *Aero. Res. Counc. Lond. Curr. Pap.* 380, 28 pp. + 6 tables + 92 figs., 1958.

Over hundred sets of published creep-rupture, creep-rate, and hot-fatigue data, mainly in the iron, nickel, chromium, and cobalt systems, were analyzed. In virtually all of these experiments the principles outlined in part I of this paper (see preceding review) were confirmed. Authors noted that ratios of constants b/k take the form 2, 4, ... 2^n. The temperature exponent A is generally 20.

F. R. Brotzen, USA

2361. Charles, R. J., Static fatigue of glass, I. *J. Appl. Phys.* **29**, 11, 1549-1553, Nov. 1958.

Water vapor corrosion of a simple soda-lime glass has been studied in regard to its effect on static fatigue of the same glass. A mechanism of dissolution has been proposed in which alkali ion self-diffusion controls the initial steps of water corrosion and leads to breakdown of the glass network. Since experiments show that an expansion of a glass network enhances corrosion rate, it is postulated that asymmetrical conditions of expansion around a surface flaw, brought about by applied stress, could lead to growth of the flaw in a preferential direction to bring about delayed failure. From author's summary

2362. Charles, R. J., Static fatigue of glass. II. *J. Appl. Phys.* **29**, 11, 1554-1560, Nov. 1958.

Static fatigue of a simple soda-lime glass has been investigated in relation to the sensitivity of this glass to atmospheric corrosion. An analysis of the failure process has been given which is based on the concept that inherent surface flaws grow by corrosive mechanisms to critical dimensions by virtue of a reaction between

water vapor in the atmosphere and components of the glass. The rate of this reaction is determined by the stress conditions around local areas and the temperature, pressure and composition of the surrounding atmosphere. Since the experimental work shows a close relationship between the temperature dependence of the failure process and that of the self diffusion of sodium ion in bulk glass it is concluded that alkali content is responsible for the very low long time strengths of most inorganic glasses.

From author's summary

2363. Clauss, F. J., and Freeman, J. W., Thermal fatigue of ductile materials. I: Effect of variations in the temperature cycle on the thermal-fatigue life of S-816 and Inconel 550, *NACA TN* 4160, 27 pp. + 19 figs., Sept. 1958.

Experimental results indicated that the maximum cycle temperature had more effect that the temperature difference on the number of cycles to failure. Increasing the cyclic time of exposure at the maximum cycle temperature improved the thermal-fatigue life at high maximum cycle temperatures, whereas the same increase in exposure time at low maximum cycle temperatures decreased the number of cycles to failure. The number of cycles to failure depends upon temperature and time effects in addition to the thermal strains absorbed by plastic flow.

From authors' summary

2364. Clauss, F. J., and Freeman, J. W., Thermal fatigue of ductile materials. II: Effect of cyclic thermal stressing on the stress-rupture life and ductility of S-816 and Inconel 550, *NACA TN* 4165, 21 pp. + 15 figs., Sept. 1958.

Exposure to thermal-fatigue conditions increased the stress-rupture strength of S-816 and weakened Inconel 550. Under the most damaging conditions studied, Inconel 550 lost 98% of its stress-rupture life after exposure to only one-half the number of cycles required to cause failure by thermal fatigue alone. When specimens were first exposed to stress-rupture conditions, the subsequent thermal-fatigue life of S-816 was sharply reduced, whereas that of Inconel 550 showed a slight increase. Existing theories of mechanical fatigue and creep-rupture are extended to thermal fatigue. Structural changes are an important part of thermal-fatigue behavior. From authors' summary

2365. Leybold, H. A., Hardrath, H. F., and Moore, R. L., An investigation of the effects of atmospheric corrosion on the fatigue life of aluminum alloys, *NACA TN* 4331, 7 pp. + 3 tables + 7 figs., Sept. 1958.

Fatigue tests were conducted on 100 vibrating cantilever sheet specimens by applying 4000 cycles of load in a 10-minute period each working day while the specimens were subjected to atmospheric conditions over a period of several months. Specimens of 2024-T3 and 7075-T6 aluminum alloys in both the bare and clad forms were tested. For comparison, 96 specimens were tested indoors. Atmospheric effects shortened the average lives of the specimens by a factor of about 3 for 7075-T6 and 2024-T3 in the bare condition and by a factor of about 1.5 for 7075-T6 in the clad condition, and had no significant effect on the average life of 2024-T3 clad specimens. From authors' summary

2366. Lazan, B. J., Fatigue of structural materials at high temperatures, *AGARD Rep.* 156, 14 pp. + 13 figs., Nov. 1957.

The importance of fatigue as a cause of service failure at elevated temperature is discussed. The general nature of the fatigue process is reviewed with special emphasis to progressive fracture and statistical aspects.

The engineering factors important in high-temperature fatigue are tabulated. The effects of various environmental conditions are generalized when justified by prior work. Special attention is paid to the effects of mean stress, alternating stress, temperature, and stress concentration. The nature and general significance of creep phenomena which occur under various combinations of cyclic stress and mean stress are discussed.

The increasing importance of resonant vibrations as a cause for fatigue is explained. The roles of damping, elasticity, and conventional fatigue properties are analyzed to provide criteria for judging resonance fatigue strength. The relative importance of these properties is illustrated by examples involving different types of materials and engineering parts.

From author's summary

2367. Bollenrath, F., Fatigue and ageing, *AGARD Rep.* 157, 9 pp. + 3 tables + 12 figs., Nov. 1957.

Paper deals with the reciprocal influence of aging and fatigue behavior. Reasons for aging are discussed briefly and results of different degrees of aging for some aluminum alloys and a mild steel are given. Also, the influence of vibrational strain on the course of aging is investigated. In addition, mention is made of the interaction between rates of diffusion and strain. From this are derived the resonance frequencies corresponding to the temperatures present during vibrational strain.

From author's summary

2368. Kaufman, A., Method for determining the need to rework or replace compressor rotor blades damaged by foreign objects, *NACA TN* 4324, 12 pp. + 10 figs., Sept. 1958.

This method includes the effects of the location and depth of damage, the material fatigue strength and notch sensitivity, and the maximum-vibratory-stress level of the blade in engine operation. The method was compared with experimental results from fatigue tests of blades edge-nicked in the laboratory and was found to be an acceptable basis for blade inspection. The amount of strength restored by reworking the damaged area was also investigated. From author's summary

Experimental Stress Analysis

(See also Revs. 2285, 2358, 2385, 2390, 2407)

2369. Taylor, C. E., Lind, N. C., and Schweiker, J. W., A three-dimensional photoelastic study of stresses around reinforced outlets in pressure vessels, ASME Ann. Meet., New York, N. Y., Nov.–Dec. 1958. Pap. 58-A-148, 9 pp.

Paper describes the three-dimensional photoelastic determination of the stresses around cylindrical outlets in spherical and cylindrical shells loaded by internal pressure. Several sizes and shapes of reinforcement were tested to study the effects of certain variables and to determine an optimum design. The results are tabulated in the form of stress-concentration factors. Distribution of the principal stresses on the surfaces of some typical models are included. From authors' summary

2370. Dally, J. W., Durelli, A. J., and Riley, W. F., Photoelastic study of stress wave propagation in large plates, AFOSR TN 58-748 (Armour Res. Found., Ill. Inst. Technol.; ASTIA AD 162 271) 12 pp. + 16 figs., Nov. 1958.

Dynamic photoelastic methods with a low modulus urethane rubber compound as the model material have been employed to study wave propagation in large plates. The loading was accomplished by using small package explosives in the form of electrical primers. The charges were placed at the corner and center of one long side of a large rectangular plate.

It was found that the photoelastic fringe patterns could in certain cases be related to the dilatational and distortional waves produced by the explosion. The effect of the reflection of the dilatational wave at glancing incidence was to increase the boundary fringe order at the leading edge of the wave by about 50%.

The maximum fringe order which moved along an interior line decayed as it propagated away from the point of load application as a function of $(1/r^{3/2})$. From authors' summary

2371. Flanagan, J. H., Photoelastic photography, *Proc. Soc. Exp. Stress Anal.* **15,** 2, 1–10, 1958.

An expression is derived for the tone reproduction of the photoelastic stress image by the photographic negative emulsion. The graph of the tone reproduction equation is utilized to illustrate the influence of emulsion, exposure and photoelastic conditions on the photoelastic isochromatic negative. By observing the influence of these variables, it is shown that no single rule can be formulated for production of an optimum isochromatic negative but rather that special rules are applicable for each particular photoelastic problem.

From author's summary by A. F. C. Brown, England

2372. Favre, H., and Schumann, W., Experimental study of the stress distribution in thick circular slabs (for various ratios between thickness and diameter) (in French), *Bull. Tech. Suisse Rom.* **84,** 10, 173–187, May 1958.

Several methods of theoretical stress analysis of slabs having relatively small thickness (membranes) are known (e.g. Kirchhoff's method). For greater thickness the problem becomes more complicated and theoretical calculations are not very accurate. Authors present and thoroughly discuss photoelastic stress analysis of thick circular freely supported slabs subject to concentrated load at the center. This optical experimental analysis was carried out at the Swiss Institute of Technology with models made of Araldite B having four different ratios between the thickness and the diameter of the slab: ½, ¼, ⅛ and 1/16, and the results were compared with stresses determined in similar way in models consisting of radial network of thin rectangular strips. Direct stresses were calculated from recorded isochromatics and isoclinics and compared with stresses calculated by Kirchhoff's method (shown in diagrams). J. J. Polivka, USA

2373. Osborn, C. J., The nature of strain-age embrittlement, *J. Iron Steel Inst. Lond.* **188,** 2, 97–100, Feb. 1958.

2374. Wells, F. E., A rapid method of waterproofing bonded wire strain gages, *Proc. Soc. Exp. Stress Anal.* **15,** 2, 107–110, 1958.

2375. Dally, J. W., Durelli, A. J., and Parks, V. J., Further studies of properties of Stresscoat under dynamic loading, *Proc. Soc. Exp. Stress Anal.* **15,** 2, 57–66, 1958.

Tests were conducted to determine the difference between dynamic and static strain sensitivities as a function of the manufacturer's coating number, the curing temperature, and the coating thickness.

It was found that the strain sensitivity is approximately a logarithmic function of the loading time, and that the largest influence of the loading time occurs for loading periods of less than 50 milliseconds. Crack visibility is a function of loading time, with longer loading periods producing more distinguishable patterns in coatings of the same sensitivity than shorter loading periods. T. J. Dolan, USA

2376. Murray, W. M., Some simplifications in rosette analysis, *Proc. Soc. Exp. Stress Anal.* **15,** 2, 39–52, 1958.

Analysis of strain or stress gages in rosettes can be simplified by multiple bridge circuits, i.e. hookups which permit reading of the gages in the rosette in various arrangements. (A stress gage is defined as a resistance wire gage so designed that its output is proportional to $\epsilon_x + \mu \epsilon_y$, where ϵ_x is the strain in the direction of the gage, ϵ_y that perpendicular to it, and μ *is* Poisson's ratio.)

Relations between strains (or stresses) measured and the principal stresses and directions are given for the four main types of rosettes. Bridge circuits are shown which measure the pertinent functions in these relations. Once they are known, a simple graphical method finds Mohr's circle of stress at the rosette.

The method is rapid and inexpensive, can be used by inexperienced personnel, and appears particularly useful for static strain or stress measurements on a fairly large number of gage points.

E. G. Chilton, USA

2377. Vasil'ev, A. V., Zakharov, V. P., and Utkin, O. L., Measurement of forces and moments (in Russian), *Vestnik Mash.* no. 9, 16–21, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5253.

2378. Riparbelli, C., Experimental solution of stress diffusion problems, *Proc. Soc. Exp. Stress Anal.* **15,** 2, 73–84, 1958.

A method for determining the stress distribution in highly redundant but essentially continuous structures is presented. The directions of the principal strains are determined experimentally using Stresscoat on the structure, or on a model of it, under actual or scaled loads. After this, the magnitude and distribution of the forces and stresses are determined by means of the conditions of equilibrium.

Examples of applications are given.

From author's summary by E. K. Frankl, England

2379. Peterson, J. P., and Updegraff, R. G., Tests of ring-stiffened circular cylinders subjected to a transverse shear load, *NACA TN 4403,* 7 pp. + 1 table + 4 figs., Sept. 1958.

Thirty-four circular cylinders stiffened by heavy rings were loaded to failure in combined bending and shear with a transverse shear load. The results are presented in the form of an interaction curve which is applicable to the design of ring-stiffened cylinders that fail as a result of local buckling.

From authors' summary

Material Test Techniques

(See also Revs. 2326, 2379)

Book—2380. Siebel, E., ed., Handbook on material testing. Vol. I. Testing and measuring devices and instruments [Handbuch der Werkstoffpruefung, Bd. I: Pruef- und Messeinrichtungen], 2nd ed., Berlin, Springer-Verlag, 1958, xvi + 890 pp.

The aim of material testing, as stated by the editor, is to obtain a complete picture of the properties of the materials by determining the essential material values. Valuable results have been achieved by testing the behavior of the material in the structural element in respect to the favorable utilization of materials, the increase in life or the appropriate use of new materials, but it has been repeatedly shown that the methods of testing strength must be further developed. The present handbook deals only with the methods of testing materials, not with their actual properties.

In the first volume the types of testing and measuring instruments are discussed. It is clearly recognizable from the first sections that less emphasis is laid on the description of the individual designs of the various firms than on the presentation of the basic principles for the solution of the task under consideration. The introduction (14 pp.) by E. Siebel shows only slight changes from the first edition. The first chapter (65 pp., P. Melchior and H. H. Emschermann) covers testing machines for static loading and has been greatly extended. The greater part is devoted to the single structural elements of the testing machine, while comparatively little space is given to the various designs. The chapter on testing machines with impact stresses (85 pp., E. Amedick and K. H. Bussmann) is similarly subdivided. The possibilities of energy production, energy and power measurement and elonga-

tion measurement under various kinds of stresses—compression, tension, bending, torsion and combined stresses, including electric measuring methods—are described in principle and illustrated by examples, reference being also made to machines for repeated impact stresses. On fatigue testing machines (79 pp., H. Óschatz and M. Hempel), a general review of purpose, accuracy and structure of the machine is followed by the description of a number of examples for tension-compression stressing, for bending tests, torsion tests, for tests with combined stresses, and finally for the testing of wires and springs and for the investigation of great structural parts. Consideration is given to the various types of drive, such as crank drive, superimposing of static forces, hydraulic drive, electromagnetic drive and the drive by forces of inertia, as well as to various devices required for measuring forces and deformations.

The chapter on hardness testing devices (27 pp., W. Hengemühle) is mainly concerned with the instruments for testing Brinell, Rockwell and pyramid-indentation hardness, for testing dynamic hardness and for measuring indentations. In comparison with others, this chapter would appear to make too little mention of machines of non-German origin. In the chapter on the investigation of testing machines (95 pp., W. Ermlich and W. Hengemühle) the methods of calibration with dead loads and by comparative tests are dealt with very briefly, although the dead load still plays an important part outside Germany. The section is mainly concerned with load-measuring instruments with which deformation is measured with mechanical, hydraulic, optical or electric aids, and with directives for the investigation of testing machines and for hardness testers, illustrated by examples. The section on loading machines for load-measuring instruments covers only machines of German manufacture. In the lengthy chapter on methods and devices for measuring deformation (148 pp., A. U. Huggenberger and S. Schwaigerer) the equipment is divided into devices for measuring displacement, extensometers and recorders, distortion, curvature and shear measuring instruments, transverse-extensometers and goniometers. The following sections deal with brittle lac methods, control instruments for measuring instruments and the evaluation of elongation measurements. In line with the rapid development of this field, a great number of instruments are described here, much space being devoted to electric and recording instruments.

In the chapter on photoelastic measuring (24 pp., L. Föppl and E. Mönch) and radiographic strain measurement (26 pp., R. Glocker) greater emphasis is laid on the theoretical bases than on the instruments. The chapter on nondestructive material testing (101 pp., R. Berthold, O. Vaupel and F. Forster) is more than three times the length of the first edition and deals with the fundamentals and instruments for x-ray and gamma-ray testing, for the magnetic powder test, the ultrasonic test and the inductive method, many examples being cited. The chapter "Devices and methods of metallographic testing" (101 pp., J. Schramm and E. Krägelöh) describes in detail the production of microsections of various metals with the required aids, metal microscopes and electron microscopes, and finally the furnaces and devices for thermal treatment. The final chapters are "Chemical analysis of metal materials" (47 pp., W. Lohrer), a survey of analysis methods for ferrous and nonferrous metals, and the "Spectrochemical analysis" (47 pp., W. Seith and H. de Laffolie), in which more prominence is again given to the instruments. A detailed index of names and articles facilitates the use of the handbook.

Due to the wide range of the subject matter and to the numbers of contributors there is a certain lack of uniformity in the book. Furthermore, in some of the fields discussed development has been almost completed; others are fairly new fields. Hence some chapters bring more fundamental outlines while others stress rather the versatility of the devices used. The majority of the instruments described are, of course, German. To obtain adequate information on the tasks of the instruments, however, it will be frequently necessary to study the following volumes of the handbook in which the methods are described. On the other hand, the present volume on the instruments is indispensable for the study of the various methods employed.

A. Krisch, Germany

2381. Spurr, R. A., Heldman, M. J., and Myers, H., The elastometer—A simple device for measurement of elastic moduli of plastics at elevated temperatures, *ASTM Bull.* no. 231, 65–67, July 1958.

2382. Autonovich, A. V., Use of automatic machines in tests for strength at high temperatures (in Russian), *Zavod. Lab.* **22,** 9, 1100–1105, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 11125.

The possibility is indicated of improving the services rendered by machines used in prolonged tests for strength of metals. For this purpose dilatometric thermocontrol is replaced by an electronic system; computing recorders are employed for the recording of the duration of sample tests; an electric scheme is proposed which provides a guaranteed cutting off of the furnace, thermocontroller and time-indicator at the moment of fracture of the sample; the adoption of a new means of temperature recording, based on the use of a self-recording galvanometer SG jointly with a bridge network, raises the accuracy of the measurement and insures centralized control of the working of the thermoregulators.

T. K. Marinets

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2383. Kitaigorodskii, I. I., Keshishyan, T. N., and Berezhnoi, A. I., Method of determining the maximum deformation when samples of glass are at disintegration point and operation of Young's modulus (in Russian), *Trudi Mosk. Khim.-Tekhnol. In-ta* no. 21, 39–44, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8506.

Apparatus is described for the measurement of the deflection indicator in the process of loading the brick (glass sample) while making the bending test. As the measure of the glass elastic limit the maximum (disintegration) deformation is taken, which is vague, as this value does not depend on the elastic limit of the material but on its brittle strength; the latter depends on the dimensions of the glass sample and its surface condition.

G. M. Bartenev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2384. Borzdyka, A. M., A review of methods employed in the mechanical testing of metals at high temperatures, Contemporary methods of testing materials in machine construction, Moscow, Mashgiz, 1956, 110–124; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8493.

Existing methods of testing metals at high temperatures are reviewed and some recommendations put forward. A description is given of the following types of testing metals at high temperatures: (1) Creep: The dilatometric relation and isothermal methods are given. (2) Prolonged strength and plasticity: The limits for strength and creep of certain metals and alloys at different temperatures are indicated. (3) Tension: The method of short-duration tests for tension is described. Optimum tension velocities for a number of test samples are indicated. (4) Fatigue: Two methods are given for the determination of fatigue limit; by the method of determining the maximum stress at which the material will not fail when subjected to prolonged loading with change of sign, and by the Lera-Shenk method. (5) Determination of hardness: A method is given for the determination of the hardness of a metal in static and dynamic tests.

In his final remarks author indicates the possibility of applying natural tests. M. R. Shamilev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2385. Bate, S. C. C., The relative merits of plain and deformed wires in prestressed concrete beams under static and repeated loading, *Instn. Civ. Engrs. Proc.* **10,** 473–502, Aug. 1958.

This paper describes a series of static and repeated loading tests on prestressed concrete beams with pretensioned steel, made to assess the relative merits of twelve different types of wire, including indented and crimped wires. It is concluded that the use of some types of deformed wires in beams may lead to higher ultimate strengths under static loading, but for repeated loading conditions their use is not normally merited. All types of wire tested were considered to provide an adequate margin of security against fatigue failure of prestressed concrete beams. From author's summary

2386. Petik, F., Accuracy of measurement with Charpy impact machines (in Hungarian), *Meres es Automat.* **6,** 5/6, 171–179, May/June 1958.

2387. Lesavre, J., Rational presentation of the results of impact tests (in French), 9th Congrès Intern. Mécanique Appl., Univ. Bruxelles, 1957; **8,** 457–461.

2388. Fichter, R., Damping of metals (in German), *Schweiz. Arch.* **24,** 3, 65–78, Mar. 1958.

Author gives a clear and up-to-date survey of internal friction in metals, covering following topics: measures of internal friction and their interrelations, static hysteresis, methods of measurement, mechanisms of energy dissipation, summary and discussion of experimental observations, internal friction measurement as a tool for nondestructive testing, bibliography. F. R. N. Nabarro, South Africa

2389. James, W. L., and Norris, C. B., An apparatus for measuring internal friction and fatigue strength of core materials used in sandwich construction, *U. S. Dept. Agric., For. Prod. Lab. Rep.* no. 1866, 21 pp. + 1 table + 19 figs., Oct. 1958.

Apparatus and techniques are described for measuring the energy absorbed by sandwich core materials subjected to rapidly cycled shear stress. Exploratory data are given on three commercial aluminum honeycomb cores with foil thicknesses of 0.002, 0.003, and 0.004 inch. From authors' summary

2390. Ayers, K. B., and Coats, R. C., Tests on struts in the elastic and plastic ranges, *Engineering* **185,** 4793, 88–89, Jan. 1958.

2391. Lynch, J. F., Quirk, J. F., and Duckworth, W. H., Investigation of ceramic materials in a laboratory rocket motor, *Bull. Amer. Ceram. Soc.* **37,** 10, 443–445, Oct. 1958.

Thirty-four different ceramic materials were evaluated as nozzle liners in a laboratory rocket motor employing oxygen and hydrogen as the propellants. The motor was operated with a four-to-one volume ratio of H_2 and O_2 and with a chamber pressure of 200 psia, giving a combustion temperature of about 4500 F. The specific impulse was about 265 seconds. Under these conditions, of the materials tried, ceramics of silicon carbide, zirconium boride, or beryllia, and a silicon-impregnated graphite were affected least. Functional life of the motor with the various experimental nozzles ranged from less than 15 to 107 seconds. A classification of the nozzle materials according to their functional life is given. Additional tests using different operating conditions in the test motor are recommended for firm conclusions on the merits of the materials as rocket liners. From authors' summary

2392. Webber, A. C., Brittleness temperature testing of elastomers and plastics, *ASTM Bull.* no. 227, 40–44, Jan. 1958.

2393. Zilova, T. K., Demina, N. I., and Fridman, Ya. B., Method of evaluating the tendency of materials to retarded disintegration (in Russian), *Zavod. Lab.* **22,** 8, 967–972, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8472.

A laboratory method is proposed for testing the comparative evaluation of the tendency of materials to retarded disintegration at low homologous temperatures. To reproduce the conditions of retarded disintegration the eccentric tension of the samples is used, the samples being notched and a testing machine with a limiting pliability being employed. It is proposed to evaluate the sensitivity of the material to retarded disintegration by the relation of short duration destructive loading to the destructive loading in a prolonged test. Using the described method comparisons were made of the sensitivity to retarded destruction of steels: ShKh 15, 30 KhGSA and alloy V 95. Yu. I. Likhachev

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Properties of Engineering Materials

(See Revs. 2269, 2275, 2279, 2315, 2326, 2357, 2359, 2360, 2361, 2362, 2381, 2383, 2388, 2391, 2400, 2415, 2435, 2675, 2678, 2679)

Structures: Simple

(See also Revs. 2250, 2280, 2281, 2294, 2295, 2298, 2355)

Book—2394. Rabinovich, I. M., Structural mechanics in the USSR, 1917–1957 [Stroitelnoi Mekhaniki v SSSR, 1917–1957], Moscow, State Publishing House for Literature on Building and Architecture, 1957, 300 pp. 13.40 rubles.

This volume consists of nine chapters, each authored by a different individual and each offering a historical resume of scientific achievements in the Soviet Union in that particular area during the 40-year period of 1917–1957.

Chapter I, "Structural mechanics of plane and spatial systems of elastic bars," by I. M. Rabinovich, treats the statics, dynamics, and stability problems of straight and curved bars. It is documented with 1082 references. Chapter II, "Thin-walled bars and systems composed of thin-walled bars" by Y. G. Panovko, discusses contributions to the statics and stability considerations of thin bars of open cross section and lists 171 reference papers. Chapter III, "Construction on elastic foundations" by B. G. Korenev, presents a summary of contributions to the area of beams and plates on elastic foundations, as well as solutions to various punch problems. It ends with 229 references. Chapter IV, "Theory of plates" by B. G. Korenev, discusses the contributions of Galerkin, Dinnik, Leibenson, Kolosov, and others and offers 333 references.

Chapter V, "Calculation of shells and other thin-walled spatial construction" by O. D. Oniashvili, presents a comprehensive resume of progress in membrane shells, shallow shells, prismatic construction, nonlinear theory, dynamics of shells, elastic-plastic considerations, and anisotropic shells. It concludes with 514 references. Chapter VI, "Dynamic calculation of structures" by Y. G. Panovko, discusses contributions to the linear as well as nonlinear theory of structural vibrations and presents 603 references. Chapter VII, "Theory of plasticity applied to structural calculations" by N. I. Bezukhov, discusses deformation theory and its application to various applied problems, ending with 275 references. Chapter VIII, "Extremal and variational principles in the theory of structures" by I. I. Goldenblat, offers a brief review of

accomplishments in this area, together with 20 references. Chapter IX, "Pressure and resistance of solid substances, calculation of retaining walls and underground structures" by G. K. Klein, discusses various contributions to soil mechanics, as well as offering 175 references.

This volume offers a splendid survey of Soviet contributions to these nine areas as well as presenting for the first time comprehensive bibliographies for each area. These are apparently quite complete as they include all dissertations completed during these years. No mention is made of any Western contributions.

W. A. Nash, USA

2395. Renzulli, T., Viscous deformation of anchored arches (in Italian), *Ingegnere* **32,** 5, 401–410, May 1958.

The plastic flow of concrete arches has been treated in early years by Straub [*Proc. Amer. Soc. Civ. Engrs.* Jan., 1930], Ch. S. Whitney [*J. Amer. Conc. Inst.* Mar. 1932] and Dischinger [*Bauingenieur* Aug., Sept., Oct., 1937 and pp. 53, 286, 426, 563, 1939] in both experimental and mathematical ways.

In the present work, the theme is based on the known exponential law of Whitney, applied to the hingeless symmetrical parabolic arch of variable section (law $I_a \cdot \cos \alpha = \text{const}$) submitted to uniformly distributed load along the span. The redundant quantities are the bending moment X_1 at clamped end and the thrust X_2. Two statical geometrical equations for the distortions are discussed, giving a system of two simultaneous equations. The integration is conducted by a double Fourier series for X_1 and X_2, and final values are obtained for v (deflection at crown), ΔH and ΔM(increment of thrust and bending moment). A numerical example is given.

The obtained theoretical curves for v and M seem to be in accordance with the experimental curves.

A. M. Guzman, Argentina

2396. Broglio, L., The method of balanced forces in science and technology (in Italian), *Monogr. Sci. Aero.*, (*N. S.*) no. 3, 134 pp., Dec. 1957.

The fundamental observation made by the author is that a system of linear algebraic equations may be easily solved by iteration when, in the matrix of the coefficients of the unknowns, the diagonal coefficients are much greater than the other. Such systems are obtained in statically indeterminate structures, solved by the method of forces, when the redundants adopted are equilibrated groups of forces producing appreciable deformations only in the immediate neighborhood of their points of action.

The basic idea of the proposed method is to obtain the solution as the sum of two partial problems, named I and II. In problem I, only equilibrated groups of forces are applied. In problem II, a reasonable assumption is made of the deformation of the structure, so that problem I amounts to a small correction of problem II. Finally, problem I is solved by iteration as indicated.

These general ideas are applied in detail to four structural problems: (a) a symmetrical plane panel with three ribs, symmetrically loaded in its plane; (b) a bisymmetrical rectangular box beam with four chords, subjected to a continuous distribution of torsional moments; (c) a symmetrical plane panel with five ribs, symmetrically loaded in its plane, (d) a plane truss of constant height with crossed diagonals in each panel. Detailed numerical computations are given for each of these problems. It is shown that any of the first three may be reduced, by use of the new method, to the solution of the differential system

$$\frac{dN}{dz} + p = C\,U;\ F\,\frac{dU}{dz} = N \quad (0 \leqslant z \leqslant L)$$

with the boundary conditions for $z = L$, $U = 0$; for $z = 0$; $N = N_L$. $C = C(z)$, $F = F(z)$ and $p = p(z)$ are given functions of z, and N_L is given. $U(z)$ and $N(z)$ are the unknowns.

This system corresponds to the physical problem of a bar with variable section, loaded by distributed axial forces and constrained in the direction of its axis by a continuous distribution of springs. The author solves it by iteration.

In the paper, the method is only applied to "elongated structures" and reviewer does not see clearly how it may be applied to the solution of more general structural problems.

C. Massonnet, Belgium

2397. Rakovshchik, Yu. A., Determination of displacements and the analysis of statically indeterminate frames stressed beyond the elastic limit (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk.* no. 4, 75–84, Apr. 1957.

A general method for the analysis of continuous beams and statically indeterminate frames loaded beyond elastic limit is given. In the inelastic ranges material is assumed to exhibit a definite linear strain-hardening property. In the basic equations of deformation, the redundant quantities are expressed in terms of curvature at the corresponding sections. Solution of equations is obtained by successive approximations. By employing curvatures as independent variables, solutions converge. Several illustrative examples are contained in the paper. E. P. Popov, USA

2398. Cassinello, F., Helical stairs (in Spanish), *Inform. Construc.* **10,** 100, 14 pp., Apr. 1958.

Purpose of the paper is to provide the designing engineer with an easy to handle tool for the analysis of helical stairs. Author points out the difficulties of a rigorous analysis, and develops the problem on the basis of the simplifications of the beam theory. The differential equations of equilibrium of a beam element are derived, using the stress resultants across the normal sections. The integration of the system of the six simultaneous linear differential equations of equilibrium leads to six integration constants, depending on the boundary conditions of the beam. These constants are given by a system of six linear equations that is obtained considering the beam as a redundant structure. In deriving the coefficients of the equations, bending and torsion deformations are considered, and shear and normal deformations are neglected. Solution is carried out for a beam double-clamped at both ends. The final matrix can be split into two matrices, one of the second order, for symmetric loading, one of fourth order, for antisymmetric loading. Paper is complemented with a numerical example.

Presentation of the paper is excellent, and exposition of the subject is remarkably well done. C. A. Sciammarella, USA

2399. Argyris, J. H., The matrix analysis of structures with cut-outs and modifications (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **6,** 131–142.

A matrix method of structural analysis previously published is summarized and extended to obtain a generalized procedure for determining the effects of structural modifications or cutouts on the stress distribution. Unit load and unit displacement methods are used and matrix formulas for each are derived in a parallel manner to clearly show the similar or dual character of these approaches. A simple translation procedure is provided for converting the matrices of one method to the other. The basic matrices are used to determine the stresses in a continuous structure under a given loading which may include thermal or other initial strains. A simple matrix formula can then be used to determine the stresses in the modified structure solely in terms of the original stresses. This procedure has the advantage that no calculations need be repeated and the order of the additional matrix required is equal to the number of stresses (or displacements) specified in the modified element. R. R. Heldenfels, USA

2400. Sheikin, A. E., and Baskakov, N. S., Experimental study of the elastic-plastic properties of concrete, obtained by a new technological process (with wet cement grouting) (in Russian), *Mosk. In-ta Inzh. Zh.-d. Transp.* no. 80/1, 400–426, 1955; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8498.

Comparative data are given in regard to the strength and the elastic-plastic properties, with repeated compression and creep, of concrete prisms 10 × 10 × 30 cm in the course of 3, 7 and 28 days, the samples having been prepared in the usual way and with a wet cement grouting, made in a grinding device reconstructed from a concrete mixer S-158. The strength of the samples with the ground cement addition with short-time compression exceeded the strength of the ordinary samples by 25% in the course of 3 days. With the lapse of time this superiority became less and after 28 days only represented 7%. In testing for repeated compression the load was passed on by stages in the range of 0.2–0.8 from the strength of the sample with short-time compression. The samples tested for creep were loaded in a 7-day increase of the axial compression force, equal to half the disintegration force in this loading stage. Similarly, the settlement deformations were measured of the unloaded samples. The results obtained in the tests showed that the use of the wet ground cement addition in no way exercised any appreciable influence on the elastic and residual deformations in identical degrees of stress of the concrete. In the earlier growth-stage of the concrete (3 days) the wet ground cement addition lowers somewhat the elastic-plastic properties of the concrete. The wet ground cement addition decreases the creep deformation of the concrete in the initial period of action of the load (30–45 days); in a 3-day period of the load action by 27%, in a 7-day, by 15%. In the later periods the difference between the relative creep deformations of the samples with the ground cement addition and without decreased. Towards the 180th day the action of the load on the creep deformation of the samples with wet ground cement addition was 14% in excess of the sample deformation without the wet ground cement addition, which the authors explain by the increase of the degree of stress in the samples with wet ground cement addition. G. S. Grigoryan

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2401. Pickett, G., and Badaruddin, S., Influence chart for bending of a semi-infinite pavement slab (in English), 9th Congrès Intern. Mécan. Appl., Univ., Bruxelles, 1957; **6**, 396–402.

For a semi-infinite slab, supported by an elastic solid subgrade for which Boussinesq equations are applicable, authors derive and construct the influence chart for the bending moment at the boundary edge, due to uniform loading over rectangular areas in the vicinity of the point where the moment is desired. The complete mathematical derivations of present problem appeared in an earlier paper [AMR **10** (1957), Rev. 3243], but the principal steps are again briefly indicated and main expressions listed. Results are later compared with charts in the supplement to Bulletin no. 65 of the Kansas State College on "Deflection, moments and reactive pressures for concrete pavements." Z. Karni, Israel

2402. Yamada, M., Rotational stiffness of a plastic hinge in reinforced-concrete beams (in German), *Beton u. Stahlbeton.* **53**, 4, 85–91, Apr. 1958.

Experiments carried out to evaluate angles of rotation at plastic hinges in reinforced-concrete beams are described and compared to the theoretical values at the instant of collapse. Proposed theoretical method is based on the assumption that plastic flow at the hinge in reinforced-concrete beam commences when cracks appear, and ceases when a certain amount of work has been done. The specific value of energy depends on the properties of concrete and the amount of reinforcement. Experimental data are not in sufficient agreement with the calculated values.

In reviewer's opinion, deformations of reinforced-concrete elements cannot be explained by the theory of plastic flow of rigid plastic bodies. A. Sawczuk, USA

2403. Scordelis, A. C., Lin, T. Y., and May, H. R., Shearing strength of prestressed concrete lift slabs, *J. Amer. Concr. Inst.* **30**, 4, 485–506, Oct. 1958.

A research investigation on the ultimate shearing strength of reinforced- and prestressed-concrete lift slabs included the testing of 15 slabs, 12 of which were prestressed with unbonded cables. All specimens were 6 ft square and had thicknesses of 6, 8, or 10 inches. The slabs were supported along all four edges and centrally loaded.

Major variables were concrete strength, amount of prestressing or reinforcing steel, amount of initial prestress, size of steel collars, thickness of slab, and amount of collar recess.

A comparison of the test results with expressions for ultimate shearing strength of reinforced-concrete slabs proposed by Elstner and Hognestad and by Whitney indicate that these expressions, with proper interpretation, may also be used for the prestressed slabs included within this series of tests.

From authors' summary

2404. Schmausser, G., Analysis of cylindrical shell roofs with longitudinal prestress by the substitute prismatic shell method (in German), *Bautechnik* **34**, 2, 44–49, Feb. 1957.

Method consists in replacing the curved shell by a series of flat plates; it has been used previously for roofs without prestressing. The prestressing wires are assumed to be either straight or with parabolic curvature in plane normal to surface. The force they exert on the roof is equivalent to two (for straight wires) or three (parabolic wires) external loads on each roof plate: (1) a longitudinal centric force at each end; (2) a couple at each end; (3) a uniform loading normal to the plate. Following cases are treated: long shells ($L/B > 2$), intermediate shells ($1 < L/B < 2$); single longitudinal span; single or multiple lateral spans: unsymmetrical loading and shape laterally; symmetrical loading and shape longitudinally; smooth load variation: constant thickness of each plate (not necessarily shell); prestress wires in shell and/or edge beams anchored at ends of roof. M. P. White, USA

2405. Eimer, Ch., Strength of a system prestressed by means of free reinforced bundles (of rods) (in Russian), *Byul. Pol'skoi Akad. Nauk, Otd.* (4) **4**, 3, 209–217, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 11019.

An investigation is made of a rectilinear prismatic component compressed by force S, created with the aid of a stressed reinforced bundle, passing along the longitudinal axis of the component. The stressed bundle touches the component at separate points and is fastened at the ends. It is established that the critical force for the component over-all (with hinged supports at the ends) will be the smallest of the Euler forces, calculated for separate segments (between the points of contact of the bundle). If the component's section is a constant, then the critical force will be the Euler force for the longest segment. If all the segments are identical in length, then when the segments number n the critical force will be determined by the expression

$$S_{kp} = n^2 \frac{\pi^2 EI}{l^2}$$

The general case of the problem of a rod with elastically fastened ends is also examined. L. I. Ulitskii

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2406. Heyman, J., and Prager, W., Automatic minimum weight design of steel frames, *J. Franklin Inst.* **266**, 5, 339–364, Nov. 1958.

The automatic plastic design of structural frames can be treated by the method of linear programming. The number of variables, however, increases so fast with the complexity of the frame that only simple frames can be handled by this method even on a large electronic computer. In the present paper a method is proposed which considers alternately two different requirements that a frame must satisfy, and thereby greatly reduces the size of the problem.

Following the introduction, part I of the paper presents the method with reference to a simple numerical example; part II establishes the general applicability of the proposed method. Part III presents some lemmas of practical importance, and some discussion, with examples, of special considerations that may arise in the design of actual frames. From authors' summary

2407. Fisher, J. W., Driscoll, G. C., Jr., and Schutz, F. W., Jr., Behavior of welded corner connections, *Welding J. Res. Suppl.* **37,** 5, 216-s—232-s, May 1958.

Authors report results of tests on straight corner connections for welded rigid portal frames. Specimens consisted of two identical members joined at right angles to form a knee. Loading was carried out until appreciable rotation occurred. Agreement with theoretical moment-deflection and moment-rotation in the elastic range was fair. All connections reached the predicted plastic moment value although some sections failed by buckling after a further small rotation. F. Ellis, England

2408. Leontovich, V., Concept of elastic parameters, *J. Amer. Concr. Inst.* **29,** 11, 987-1008, May 1958.

Paper derives formulas for quantities, called elastic parameters by author, which are combined to provide flexural constants for curved members such as arch ribs and portal frames. Normally these parameters are then used to compute constants with reference to elastic center of the curved member. Author's method differs from the basic method in that elastic parameters are defined for the pin-ended member and then adjusted, by using the equivalent of transfer theorems, to the elastic center. It appears, however, that these ultimate constants are as readily computed directly from basic principles without injecting the additional definitions of the several elastic parameters.

Author asserts that tedious semigraphical integration involved in the usual method of analysis of structures comprising curved members is completely avoided by the use of previously tabulated values of elastic parameters and load constants. This statement, however, is equally true when made with reference to tabulated values of basic constants for families of curved members if such tables were available. J. E. Goldberg, USA

2409. Strel'bitskaya, O. I., Limiting load of single contour frames under the action of forces perpendicular to the frame's surface (in Russian), *Dop. URSR* no. 4, 344-348, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8241.

The limiting state is investigated for a single contour frame of thin-walled girder profile when subjected to simultaneous torsion and bending. The load is in the form of a concentrated force, perpendicular to the surface of the frame and applied to the center of the crossbar with eccentricity. The frame material is assumed to be ideally plastic. As a condition of flow, use is made of the constancy of the tangential stresses. The carrying capacity of the frame is assumed to be reached at the moment of formation in it of plastic hinges, the number and distribution of which depend on the relation of the length of crossbar l to the length of the frame's bracing h_0. It is assumed that in the place of the plastic joint the flow spreads over the whole of the cross section. Formulas are advanced for the determination of the limiting load, obtained by a scrutiny of curves of normal and tangential stresses in the limiting condition. Curves σ and τ are assumed to be rectilinear. No account is taken of the tangential stresses due to transverse forces and the deflection-torsion moment. The formulas mentioned for the limiting load were obtained to meet the case where the limiting condition sets in on the appearance of two plastic hinges at the point of fastening of the bracing (when $l < h_0$), and the case where the limiting condition is characterized by the appearance of three plastic hinges on the crossbar, or by a plastic hinge in the center of the crossbar and two plastic hinges at the joint of the bracing (when $l > h_0$). E. A. Raevskaya

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2410. Heyman, J., Minimum weight of frames under shakedown loading, *Proc. Amer. Soc. Civ. Engrs.* **84,** EM 4 (*J. Engng. Mech. Div.*), Pap. 1790, 25 pp., Oct. 1958.

The first part of the paper discusses the minimum weight design of framed structures under both fixed and independently varying loads. A simple numerical example is given, for which the complete solution is obtained, and the results corresponding to the two types of loading are compared.

An iterative method is then presented for the minimum weight design of a frame of any degree of complexity; this iterative method may lead to results which are slightly inexact.

From author's summary

2411. Dellart, R. C., Dynamic effect of a moving load on a rigid frame, *Proc. Amer. Soc. Civ. Engrs.* **84,** EM 4 (*J. Engng. Mech. Div.*) Pap. 1794, 25 pp., Oct. 1958.

A procedure for determining the response of a rigid frame structure subjected to a distributed load moving at a constant velocity is described. It is demonstrated that a single impact factor is not applicable to all parts of the frame. In addition, tables are presented which facilitate the handling of a distributed load of variable intensity.

From author's summary by I. M. Viest, USA

2412. Polx, K., Frameworks with movable joints and harmonic dynamic loading (in German), *Bautechnik* **35,** 2, 50-58, Feb. 1958.

A dynamic analysis is given for elastic, inextensional frameworks under harmonic excitations. Joints are free to rotate and translate. Mass of columns is neglected; masses of floors seem included only in translational equations of motion. System of linear algebraic equations resulting from equations of rotational and translational equilibrium and compatibility at the joints is solved by conventional methods. Effects of joint displacement, elastic foundations, and structural approximations of an actual framework are demonstrated in the dynamic response to various loads. F. T. Geyling, USA

2413. Besseling, J. F., Application of matrix calculus in adjusting stiffness and vibration properties of redundant structures (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **6,** 168-175.

A method is given to derive the displacements and flexibilities of a structure, which has been changed by means of additional elements or supports, from the already calculated displacements and flexibilities of the original structure. The computation consists of inverting a matrix of the same order as the number of stiffness variations, followed by one multiplication of the displacements and flexibilities by the so-called modification matrix.

The method described leads to a considerable reduction of the number of numerical operations which have to be performed to find the displacements and flexibilities of the modified highly-redundant structure.

From author's summary by C. Massonnet, Belgium

2414. Fung, Y. C., and Barton, M. V., Some shock spectra characteristics and uses, *J. Appl. Mech.* **25,** 3, 365-372, Sept. 1958.

As defined by the authors "A shock spectrum is a plot showing the peak response of a linear variable-frequency oscillator (of single degree of freedom) to a specific shock wave, as a function of the frequency of the oscillator." They quite rightly point to Biot as the originator of the shock spectrum in connection with applications to engineering seismology. The authors, however, limit their own studies to the single-pulse-type shock for which they tabulate

nine properties of the shock spectrum, four of which are considered to be new.

The particular value of the paper lies in its detailed exploration of the effect of pulse shape, particularly during the time of rise of the forcing function, on the characteristics of the shock response spectrum, including an evaluation of peculiarities for zero and for very large values of frequency. Authors finally conclude (after a study of the cantilever beam shock problem) that "The amplification spectrum is rather insensitive to the details of the exact history of the pulse." Nevertheless, their results show that for a limited frequency range there is a relatively large sensitivity of the amplification factor with respect to minor differences in pulse shape during the time of rise for two pulses of a blast type that have the same total impulse. Similar studies of minor variations during the time of rise of the blast pulse might well receive further study.

Since the authors are concerned primarily with a single pulse shock they give relatively little attention to the effect of damping. Ordinary viscous damping is included in the formulation of the problem and thegreater importance of damping is pointed to in the case of multiple shocks such as result from earthquake. The initial spectrum studies by Biot did not include the effect of damping; it was later introduced into the spectrum plots by Housner. It may be noted that there is a more than ten to one discrepancy in response levels established in undamped earthquake shock spectra as compared with the actual response of buildings that have survived earthquake with little or no damage. In view of the major importance of damping in connection with earthquake phenomena, authors might well have omitted conclusions which pertain to the earthquake-type multiple shock. B. G. Johnston, USA

2415. Medvedev, S. V., Influence of internal frictional forces in the vibrations of buildings in earthquakes (in Russian), *Trudi Geofiz. In-ta Akad. Nauk SSSR* no. 36 (163), 114–126, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8389.

The damping influence is investigated of the internal friction in an installation as the result of the change of spectrum action $x = x_0\psi(T)\epsilon(\lambda)$ with the change of the logarithmic decrement of damping λ. For buildings with fundamental vibration periods of $T = 0.17 - 2.65$ sec, values for λ were obtained varying within the limits of from 0.15 to 0.37. $\epsilon(\lambda) = 1$ when $\lambda = 0.5$ is assumed and its values are determined with different values of λ, as the result of which the relation $\epsilon = 1/\sqrt{2\lambda}$ is proposed, within the limits of change of λ from 0.15 to 2.0. B. K. Karapetyan

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Structures: Composite

(See also Revs. 2256, 2351, 2394, 2438, 2710)

2416. Yakobson, K. K., Some dynamic characteristics of suspension bridges (in Russian), *Trudi Novosibir. In-ta Inzh. Zh.-d. Transp.* no. 12, 102–117, 1955; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8378.

In order to determine approximately the frequency of the vertical vibrations of a three-span continuous rigid girder it is proposed to take the mean value of the frequency coefficients from their values for a simply supported and a fixed girder of the mean span. The check of the dynamic stability and the determination of the frequency of the horizontal vibrations, it is proposed, should be carried out according to known formulas. An analysis of the dynamic characteristics of the Takomskii bridge confirms the real losses of dynamic stability. The accuracy of the determination of the dynamic characteristics is checked by a set of examples.

N. K. Snitko

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2417. Benthem, J. P., The enclosure of the flexibilities, the cross-flexibility included, of infinite hollow box beams with oblique ribs (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **6**, 160–167.

Moment-rotation relationships of sweptback rectangular box beams bounded between minimum complementary energy and minimum potential energy. Analysis assumes (1) spar and rib webs carry shear stress only, with normal-stress carrying capacity added to edge stiffeners (booms), and (2) stringers continuously distributed to skin to form orthotropic plate top and bottom. Author compares results by numerical example to solutions by Hemp, Wittrick, and Flügge. Striking coincidence is shown with Hemp solution which is also for rectangular section and finite cross-flexibility. Wittrick-Flügge solution, based on arbitrary cross section and infinitely stiff ribs, is far outside author's bounds. Apparent error in computing effective spar boom area (boom plus web contribution) may account for Hemp solution falling slightly outside author's bounds. While author's solutions are approximate, bounds allow judgment of accuracy.

G. P. Fisher, USA

2418. Riparbelli, C., Nonextensional deformation modes of thin plates (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **6**, 442–447.

Paper first discusses the problem of bending of a thin long rectangular plate acted on by two oblique, equal and opposite, bending moments at two edges. It is assumed that bending is uniform; that the plate with the free edges deforms into a developable surface (zero Gaussian curvature) and that the parabolic points form straight and parallel generators the angle of which, formed with the sides of the plate, is the unknown of the problem. Using the energy method author finds that this angle equals half the angle of the external moment vector. Second part deals with the more general case of bending of plates of any shape and under any load distribution, assumed again to deform into developable surfaces with straight but not parallel generators. An amplifying factor, denoting the ratio of the strain energy per plate segment to that of the first case of pure oblique bending, is introduced and plotted for plates and some airfoil-shaped sections. Some aspects of the experimental verification are illustrated.

Z. Karni, Israel

Machine Elements and Machine Design

(See also Revs. 2260, 2333, 2430, 2431, 2746)

2419. Trylinski, W., Design of tooth profile for constant torque in gear drives (in German), *Feingeratetechnik* **7**, 7, 317–323, July 1958.

Author considers problem of designing tooth profile in gear drives (for example, in clock mechanisms) so as to obtain constant output torque, effects of friction between gear teeth being considered. Graphical methods for obtaining tooth profiles giving constant torque are presented for (1) driving gear with involute profile and (2) both gears having straight line profiles for the root portions. It is suggested that small modifications in tooth profile for usual clockwork gearing may greatly reduce variations in instantaneous output torque. A. M. Wahl, USA

2420. Mehan, R. L., Irradiation of Haynes-25 and Inconel-X compression springs in high-temperature high-pressure water, ASME Ann. Meet., New York, N. Y., Nov.–Dec. 1958. Pap. 58-A-94, 7 pp.

Irradiation tests were performed on Haynes Stellite Alloy 25 and Inconel-X springs irradiated in the compressed condition in an in-

pile high-temperature water loop. The loop was operated at 560 to 600F and the springs of both materials received integrated fluxes of 5.9×10^{18} and 4.2×10^{19} nvt fast, respectively. Postirradiation testing and examination revealed no serious deleterious effects resulting from these exposures. It was found the spring constant increased 5 to 8% after exposure and the free length decreased 2 to 3%. The effect of irradiation on the plastic-flow curve was slight as revealed by three-point loaded bend tests on 0.160-in.-diam rods irradiated with the springs.

From author's summary

2421. Maier, K. W., Your guide to springs that store energy best, *Prod. Engng.* **29,** 46, 71–75, Nov. 1958.

2422. Bondy, P., Graphic kinematics of straight plate springs (in Hungarian), *Meres es Automat.* **6,** 5/6, 164–171, May/June 1958.

Author presents elementary but comprehensive derivation of displacement characteristics of prismatic flat (plate-type) springs. Deflection functions are derived for the spring fixed at one end and subjected to shear, moment and thrust at the other, as governed by different boundary conditions.

The case of plane translation by two parallel springs is treated in detail. Springs containing a stiff central piece are shown to entail less reduction in span during parallel translation than prismatic (uniform) springs of the same stiffness. Cautionary note is added on the strong influence of thickness tolerances upon resulting performance. N. A. Weil, USA

2423. Helke, G., Investigation of the stability of nonlinear forced vibration with one degree of freedom (in German), *Dtsch. Versuchsanstalt Luftfahrt Rep.* 55, 20 pp., May 1958.

Stability of the periodic responses of a nonlinear damped spring to harmonically varying applied force is obtained by a method of Poincaré. The method employs perturbation series in powers of the amplitude of response for displacement, velocity, and period. In agreement with Klotter and Pinney [AMR **6** (1953), Rev. 3320] and contrary to results of certain others, it is found that the response is stable if its amplitude increases with small increase in amplitude of the forcing function.

C. M. Ablow, USA

2424. Gardiner, F. J., and Carlson, H. C. R., The spring back of coil springs, *Mech. Engng. N. Y.* **80,** 4, 74–76, Apr. 1958.

2425. Hampl, M., Stress in an infinite plane with (a) two, (b) an infinite row of shrink-fitted circular pins (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **6,** 40–46.

When a pin is shrink-fitted into a plate of infinite extent, the stress and strain in both the plate and the pin can be derived from the appropriate stress functions. By superposition of such stress functions the stress is calculated in both plate and pins when two pins are shrink-fitted into the plate, and the method is then extended to the case of an infinite row of pins shrink-fitted into the plate. In the last case the solution is given in a closed form by the use of a well-known identity. Results are discussed quantitatively and stress diagrams are given.

J. Fulton, Scotland

2426. Val'ter, A. A., Determination of losses due to stiffness of steel cables because of the small angles of contact of the pulleys (in Russian), *Trudi Penzensk. Industr. In-ta* no. 3, 24–48, 1955; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8451.

The results are given of tests made on special apparatus which allowed for changes of angles of contact of the cable with the pulley with different loadings on the cable. The angular bending of the cable varied from 2 to 80°; the stress on the tensioned wires of the cables under test from 8.7–31 Kg/mm². Two cases were investigated: contact angle of the pulley less than, and greater than the critical. By critical angle is understood the angle at which the cable touches the pulley at one point. Tests for the determination of the critical angle of bending arising from a lack of strength in the cable are not forthcoming in the paper. The following deductions were obtained: (1) the losses due to cable stiffness at angles of contact greater than the critical are constant and are determinable by means of K. M. Maslennikov's formula put forward in his dissertation ["The stiffness of steel cables when being bent," L., LPI im. Kalinin, 1949]; (2) at contact angles less than the critical, the losses decrease approximately in proportion to the decrease in the bending angle; (3) the magnitude of the critical angle of bending depends on the diameters of the pulley and cable; (4) the losses in an assembly of pulleys depend on the general angle of bending in the assembly and the diameter of the pulleys. B. D. Tikhovidov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2427. Sokolovskii, B. I., and Sokolokskii, V. I., Calculation of mine hoisting ropes (in Russian), *Sb. Statei Ural'skogo Politekhn. In-ta* no. 56, 39–46, 1955; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4687.

An examination is made of the problem of longitudinal oscillation of a rope of variable length occuring when a freely suspended load is lifted or lowered. At the same time a method of calculating the dynamic stresses in a hoisting rope is developed on the basis of N. E. Zhukskii's results ["Hydraulic impact in water pipes." In: Collected Works, Vol. 4, Gostekhizdat, 1949]. Assuming that the cable can be considered as an ideal elastic rope and that slipping of the cable over the drum can be neglected, authors reduce the problem to solution of the system of different equations

$$\left(\frac{\partial T}{\partial t} + c\,\frac{\partial T}{\partial x}\right) = \rho c \left(\frac{\partial \nu}{\partial t} + c\,\frac{\partial \nu}{\partial x}\right)$$

$$\left(\frac{\partial T}{\partial t} - c\,\frac{\partial T}{\partial x}\right) = -\rho c \left(\frac{\partial \nu}{\partial t} - c\,\frac{\partial \nu}{\partial x}\right),$$

where T denotes the dynamic stresses, c the rate of propagation of an elastic wave, ν the rate of displacement of the section with the coordinate x, and ρ the mass per unit run of the rope.

This solution differs from the known solutions of other authors, in which both the rate of transfer motion of the rope and its incomplete elasticity are taken into account [see, e.g., N. P. Neronov, *Prikl. Mat. Mekh.* **1**, no. 1, 1937]. V. N. Shevelo

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2428. Worthley, W. W., and Hinkle, R. T., Four-bar linkages—approximate synthesis, ASME Ann. Meet., New York, N. Y., Nov.–Dec. 1958. Pap. 58-A-130, 4 pp.

An analytical method for synthesizing a four-bar linkage as a function generator is presented. The method, which permits the arbitrary selection of four precision points and finite angular ranges, is based on a graphical solution. This permits a preliminary graphical investigation of the six possible linkages before selecting one for analytical treatment.

From authors' summary

2429. Wolfe, W. A., Analytical design of an Ackermann steering linkage, ASME Semiann. Meet., Detroit, Mich., June 1958. Pap. 58-SA-31, 4 pp.

Vehicle front wheel angles of rotation approximated by a symmetrical four-bar linkage. Adjustment of coefficients in equation determines physical proportions. Approximate solution using power series is utilized. A useful contribution to synthesis of four-bar linkages. C. R. Freberg, USA

Fastening and Joining Methods

2430. Marriner, R. S., and Wood, J. G., (Mrs.), Rake correction in the measurement of parallel external and internal screw threads, Instn. Mech. Engrs., Prepr., 9 pp., 1958.

Formulas are derived for calculating the rake correction for a ball seated in the helical groove of an internal screw thread and a ball or cylinder in an external thread. The equivalence of a ball and cylinder in an external thread is discussed. A simple approximation formula and a precise formula are derived for determining when double contact between the cylinder and thread flank occurs. From authors' summary

2431. Donald, M. B., and Salomon, J. M., Behaviour of compressed asbestos-fibre gaskets in narrow-faced, bolted, flanged joints, Instn. Mech. Engrs., Prepr., 3-8, Dec. 1957.

2432. Habel, R., Forces on a universal joint (in German), *Maschinenbautechnik* **7,** 5, 289-296, May 1958.

Author's aim is to determine the variation of the bending moment acting on two shafts intersecting each other at an angle α and connected by a universal joint, as a function of the angle φ_1 described by the driving shaft.

After a demonstration of the well-known relation between the angular velocities ω_1 and ω_2 of the two shafts, the forces acting on the plane formed by the two arms are analyzed for the angles $\varphi_1 = 0$ and $\varphi_1 = \pi/2$, and the bending moments arising on the driving shaft (for $\varphi_1 = 0$) and on the driven shaft [for $\varphi_1 = (\pi/2)$] are deduced as a function of the angle α and the driving torque M_1. The problem is then treated in its generality and the bending moments acting on the two shafts are calculated for any angle φ_1 as a function of α and M_1; the axial forces working on the shafts are studied. For the calculation of the ball bearings, the mean of the cubic force (P^3) acting on the driving and on the driven shafts for a period $0 - (\pi/2)$ of angle φ_1 is used and an example of calculation of the reaction is given. The determination of the bearing reactions is then extended to different cases where an intermediate shaft is used, namely when the driving and driven shafts are parallel, when they are symmetrically inclined against the intermediate shaft, and when they cross each other. Finally, author shows how it is possible to check graphically the results of calculation. D. de Meulemeester, Belgium

2433. Adams, C. M., Jr., Cooling rates and peak temperatures in fusion welding, *Welding J. Res. Suppl.* **37,** 5, 210-s—215-s, May 1958.

Using two formulas of D.Rosenthal [*Trans. ASME* **68,** p. 849, 1946] for the temperature distribution about a moving heat source, author establishes approximate expressions for the peak temperature developed at a given (arbitrary) distance from the line of weld, and for the cooling rate along the line of weld.

G. Horvay, USA

2434. Grimes, D. L., Application of structural adhesives in air vehicles, *AGARD Rep.* 181, 10 pp. + 11 tables + 13 figs., Mar.-Apr. 1958.

Report deals with the use of adhesives as structural joint media, for both aircraft and missiles. A systematic and detailed discussion is presented of the advantages and disadvantages of adhesives. From author's summary

Rheology

(See also Revs. 2266, 2269, 2460, 2506, 2608)

Book—2435. Mason, P., and Workey, N., The rheology of elastomers, Proceedings of the Welwyn Garden City conference, May 1957; New York, Pergamon Press, 1958, viii + 202 pp. $8.50.

Proceedings of conference of British Society of Rheology at Welwyn Garden City, May 29-31, 1957. Book consists of unconnected individual papers, some of review nature, some reporting original research: *L. R. G. Treloar*, The present status of the theory of large elastic deformations; *P. Thirion and R. Chasset*, Thermodynamics of rubber in extension: A study of the relation between tension and temperature at equilibrium. Part I. Reversibility and method of analysis; *D. W. Saunders*, The photoelastic properties of rubber-like polymers; *P. R. Saunders and A. G. Ward*, A note on the elasticity of gelatin gels; *G. Gee, G. Allen and B. E. Read*, An experimental study of stress relaxation and viscous flow in natural rubber; *J. Scanlan*, Network theories of stress relaxation and set in rubber; *A. S. Lodge*, A theory of elastic recovery in concentrated solutions of elastomers; *A. R. Payne*, Temperature-frequency relationships of dielectric and mechanical properties of polymers; *H. W. Greensmith*, The tearing of rubber; *A. Charlesby and E. Fukada*, Dynamic viscoelasticity of polyester cured by irradiation; *J. J. Benbow*, The recovery behaviour of polythene at large strains; *A. Charlesby, J. Burrows and T. Bain*, Mechanical properties of irradiated filled rubber; *P. L. Clegg*, Elastic effects in the extrusion of polythene; *E. L. Foster and H. Heap*, High-temperature tensometry and its application to amorphous polyethylene terephthalate.

Papers by Treloar and by Scanlan are critical reviews of important subjects. Lodge's paper advances new treatment of elastic recovery; Clegg's experimental study on extrusion is contribution to industrially important subject.

I. M. Krieger, USA

2436. Shesterikov, S. A., On a variational principle in creep theory (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 2, 122-123, 1957.

Author considers a body in a creeping status and subject to the prescribed boundary conditions. Using the components of the stress tensor, author constructs a variational principle over a three-dimensional volume of the body in question. Application of the variational procedure with respect to some parameters which may enter into the functions in question furnishes a three-dimensional integral involving such functions as the invariant of the plastic deformation tensor, etc.

M. Z. v.Krzywoblocki, USA

Hydraulics

(See also Revs. 2531, 2532)

2437. Gerber, R., On a class of solutions of the equations of motion of a liquid with free surface (in French), *Ann. Inst. Fourier Univ. Grenoble* **7,** 359-382, 1957.

Author gives an extension of his thesis mentioned in AMR **9** (1956), Rev. 2620, concerning the existence of solutions for two-dimensional steady flow of an ideal fluid with free surface over a given bed.

The condition of complete continuity could be satisfied by the assumption of geometrical periodicity or a quantity in the free surface condition being small everywhere. This quantity is the ratio between discharge times, acceleration of gravity, and third power of the free surface velocity.

The latter artifice was useful for rapid flow but not valid for tranquil flow with slopes of bottom and free surface of opposite signs. The difficulty at infinity is avoided, in the present article, by the *a priori* assumption of geometrical periodicity.

Attention is given to the case of small slope and large longitudinal period as compared to the mean depth.

H. J. Schoemaker, Holland

2438. McBirney, W. B., Some experiments with emergency siphon spillways, *Proc. Amer. Soc. Civ. Engrs.* **84,** HY 5 (*J. Hydr. Div.*), Pap. 1807, 24 pp., Oct. 1958.

Two model designs of low head siphon spillways were tested. One is patterned after a standard design used for many years as an emergency-type of structure for the protection of canals. The second is a proposed design for an improved structure to perform the same function.

Operational characteristics and peculiarities of each are discussed and supporting data and pictures are included. The results of one prototype test of a standard design are also given. In the conclusions, studies of both designs are reviewed and future tests are outlined. From author's summary

2439. Slissky, P. M., Calculation of the discharge capacity of pressure spillways (in Russian), *Trudi Mosk. Energ. In-ta* no. 19, 125–135, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6643.

A critical examination of the existing method of calculating the discharge capacity of pressure spillways. The insufficiencies and incongruities which can arise through application of the Bernoulli equation to a section including a hydraulic jump as well as the pressure spillway are indicated, as well as the method of determining the flow coefficient in the discharge cross section of the spillway, the summary determination of all resistance factors, as influenced by the conditions in the spillway discharge corresponding to different types of linkage of the pounds.

A. G. Chanishvili

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2440. Lebedev, I. V., The present status of the hydraulics of local scour behind spillways on lowland rivers (in Russian), *Izv. Vses. N.-i. In-ta Gidrotekhn.* **55,** 96–103, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6688.

A short survey is given of the work of Soviet scientists in the theory of local scour caused by a free-falling flow or a current falling over a horizontal sill. B. I. Bek-Marmarchev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2441. Adzerikho, S. Ya., Problem of the hydrotechnical calculation of a spillway dam on peat foundations (in Russian), *Trudi In-ta Melior. Vod. i Bolot. Kh-va Akad. Nauk BSSR* **6,** 266–280, 1955; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5813.

2442. Chernov, Yu. V., Velocity distribution in natural river bed flows (in Russian), *Tr. In-ta Nefti, Akad. Nauk* KazSSR **1,** 88–89, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10315.

The question is discussed on the "section quality" of open flows of various forms (relation of the mean value of the whole section or even of the axial vertical to the maximum local velocity). Author deduces that the velocity field has not so far been established as a precise function of the distribution by width of the section of local depths and of the relative roughness, which point is confirmed by him in a series of given measurements and by a critical analysis of the semi-theoretical propositions (native and foreign) on record. V. N. Goncharov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2443. Sukhomel, G. I., and Nikitochkin, O. G., Eddy formation in front of shields partitioning off canals (in Russian), *Tr. Kievsk. Gidromelior. In-ta* no. 5, 21–27, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10348.

Laboratory experiments are described and some theoretical concepts are presented dealing with the problem under examination.

From the authors' observations it appears that when there is a flow of water from under the shield partitioning a canal of rectangular section, two symmetrically placed eddies are formed on the sides in front of the shield. The level of the water at the shield rises somewhat, the increase being larger at the center of the shield. The deduction is made that because of the uneven rise of level beside the shield a current is formed heading to the corners, and then along the side-walls against the original flow in the trough, which is possible if there is a water layer next to the walls with small velocities. The last, in the authors' view, is the cause or one of the causes at least of the formation of eddies. In the experiments carried out the intensity of the eddies was characterized by the carrying capacity of the eddies, namely: the quantity of uniform objects passing through the eddies in a fixed time interval. According to the experimental data, as the intensity of eddy-formation increases so does the velocity coefficient φ decrease, and the capacity of the orifice fall. By neutralizing the effect of the eddies by means of plates, stopping reverse currents at the shield, coefficient φ increases by 1.5–3%. Eddy formation takes place in both heated and unheated flows. Authors also repeated the experiments of V. S. Fokeev [*Gidrotekhn. Str-vo* no. 5, 1951; *Gidrotekhn. i Melioratsiya* no. 12, 1951]. The shield recommended by them, a shield-vortex-former, resulted in an increase of the eddy intensivity. N. A. Prituits

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2444. Marris, A. W., Large water-level displacements in the simple surge tank, ASME Ann. Meet., New York, N. Y., Nov.-Dec. 1958. Pap. 58-A-29, 7 pp.

The nondimensional unapproximated form of the equation describing the motion of the water level in a simple nonthrottled open surge tank operating under the condition of constant hydraulic power to the turbine is shown to have two singular points. One of these is at the steady-flow hydraulic grade-line level and accounts for small displacement phenomena. The other is at a lower elevation and accounts for the occurrence of drainage due to insufficient power being available at the turbine.

An approximate condition for the occurrence of drainage of this type is given for the case of sudden acceptance of full load from a zero-flow condition. This result and the condition for the perpetuation of oscillations of constant amplitude are compared with experimental data obtained by the author from a hydraulic model.

From author's summary

2445. Numachi, F., Tsunoda, K., and Chida, I., Cavitation tests on hydrofoils of simple form: Rep. 3, On four profiles of thickness ratio 3.5 percent; Rep. 4, Difference in performance between experiments with water temperatures of 8 and 20 deg. C; Rep. 5, On four profiles of 11.7 percent thickness ratio; Rep. 6, On three profiles of 3.5 percent thickness ratio (in English), *Rep. Inst. High Speed Mech., Tohoku Univ.* **9,** 81/90, 35–48; 49–69; 71–88; 89–103, 1958.

The four papers cited above appear to form part of a sequence of reports in English from Tohoku University. Reviews of previous papers in this series are contained in AMR **11** (1958), Revs. 4071, 4072, 4073 and 4074. This series summarizes results of water-tunnel tests on forty hydrofoil profiles. Evidently this ambitious experimental program was completed prior to 1950, which date precedes the start of similar but much less extensive programs in this country.

The present four reports concern cavitation test results on a total of sixteen profiles, each section having a thickness ratio of 3.5, 7.0 or 11.7%. The purpose of the work was to develop hydrofoil sections which have good hydrodynamic performance and which are easily fabricated. For this reason the shape of nearly all sections tested was defined by segments of circular arcs and straight lines. All experimental results reported for lift and drag coefficients are tabulated in terms of cavitation number and angle of incidence. No moment coefficients are reported. Water temperature

and dissolved air content are given for each series of tests. Cavitation diagrams, which record cavitation development on the profile, are also presented. No information on precision of measurement or experimental scatter is given.

In their Report 4, authors attempt to assess the effect of water temperature upon the test results for temperatures between 8 and 20 C. It was found within the range of Reynolds numbers obtained that changes in this parameter produced little effect upon cavitation performance. The important variable appeared to be the cavitation number. In cavitating flow the lift and drag coefficients showed trends which depended upon the water temperature. Reviewer believes that such trends may not have been obtained had the authors found it possible to use cavitation numbers based upon measured cavity pressures instead of the vapor pressure of the water [AMR 11 (1958), Rev. 1759]. In all tests the dissolved air content was held close to the saturation value at each temperature and it is known that the solubility of air in water varies by nearly 20% over the temperature range of the tests. Therefore it seems possible that those test results which involved cavity flows may have been influenced by variations in the rate of air diffusion into the cavities. B. R. Parkin, USA

2446. Portnov, I. G., The front boundary of the cavitation region (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 3, 99–107, Mar. 1957.

Portnov considers the stability of a stationary temperature field in a moving medium in which there exists a surface phase transformation. In particular, author treats cavitation problems. The front boundary of the cavitational region is defined as the boundary between the incoming flow and the cavitation region. When the cavitation is fully developed the front boundary is a free boundary (analogous to wakes and jets) and the velocity component normal to it is zero. On the other hand, the "developing" cavitation is connected with a turbulent velocity and with a phase transformation (into steam). Therefore, as the boundary in the second case one can assume the surface on which there begins an intensive phase change. Starting from the first law of thermodynamics and Bernoulli equation (inviscid medium), Portnov derives a temperature equation (ordinary, second-order) whose solution with the appropriate boundary conditions provides sufficient criterion for the existence or non-existence of a certain type of front boundary. In the case of a cavitation phenomenon, a developing front boundary cannot exist; there may exist only a free boundary surface. Portnov considers the derived criterion as a fundamental rational classification of cavitation phenomena.

M. Z. v. Krzywoblocki, USA

2447. Kvyatkovskii, V. S., The cavitation properties of hydroturbines (in Russian), *Tr. Mosk. Energ. In-ta* no. 19, 329–353, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10371.

From Bernoulli's equation for the absolute and relative flow through a turbine the cavitation coefficient is found. Assuming that the velocity triangle at the outlet is evenly ribbed and substituting the velocities by velocity coefficients, which are constant for geometrically similar turbines, author deduces an equation for the determination of the cavitation coefficient of the actual turbine in accordance with the known data of laboratory-scale cavitation tests carried out on a model of the turbine. The practical value of the formula obtained should be experimentally confirmed. A quantitative method of evaluation is put forward to ascertain the influence of shape of the separate working parts of the turbine on the turbine's cavitation properties. An investigation is made of the influence of the helical form of the shape of the controlling apparatus, of the suction tube, and of the position of the shaft. On the basis of the formulas obtained a comparison is made of horizontal and vertical turbines, identical as regards dimensions, with identical depth of indentations and cavitation expectation for a bent and axially straight suction tube. The superiority is indicated of the horizontal turbine with an axially straight suction tube. Taking into account the higher efficiency (k.p.d.) of horizontal axial articulated-bladed turbines, the shallower foundations, the presence of power reserve for the pre-flooding period, the question is raised regarding the wide adoption of this type of turbine. I. I. Orlov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2448. Krupinin, V. G., Savelyev, B. A., and Sheypak, A. A., Cavitation in some parts of aircraft engines (in Russian), *Trudi Mosk. Aviats. In-ta* no. 64, 81–87, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6624.

A brief exposition is given of problems associated with cavitation. Results are described of investigations on the mechanism of cavitation with the help of magnetostriction generators. The bubbles formed in cavitation contain, in addition to water vapor and air, also minute particles of water. The envelopes of the cavitation bubble and the water droplets contained in them carry electrical charges of different sign. Under compression, discharges take place within the bubbles which, in the opinion of the authors, are one of the main causes of the physical-chemical action of cavitation on metals. A further cause of cavitation is the tremendous pressures (of the order of several thousand atmospheres) generated at the destruction of a cavitation bubble. Researches have shown that attack always takes place in the region of breakdown of the cavitation bubbles.

Measurements of the temperature within cavitation bubbles have shown that the value is approximately 200°. Hence authors question the hypothesis of L. A. Epstein that the cavitation process is isothermal [*Trans. CAHI*, no. 584, 1946].

Investigating the action of an injector nozzle, authors demonstrate that in the outflow of an incompressible fluid from a calibrated orifice, the monotone relationship between the volume of flow of the liquid and the pressure gradient is not always valid, which is the reason for the appearance of cavitation.

Yu. A. Lashkov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2449. Arkhangelskii, V. A., Calculation of the motion of gas-liquid mixtures in vertical pipes (in Russian), Gidrodinamika i teploobmen pri kipenii v kotlakh vysokogo davleniya, Moscow, Akad. Nauk SSSR, 1955, 35–45; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4457.

Incompressible Flow

(See also Revs. 2437, 2462, 2501, 2511, 2513, 2516, 2527, 2534, 2542, 2544, 2601, 2621, 2622, 2692, 2712, 2723, 2745)

2450. Karas, K., Steady laminar flow through circular pipes and annular pipes, with fixed and moving interior walls, under a steady pressure gradient (in German), *Öst. Ing.-Arch.* 11, 4, 306–318, Dec. 1957.

Paper is concerned with fully established laminar flows in circular and annular tubes. Author solves a number of problems in which the pressure gradient is not constant at any cross section by means of a membrane analogy. The standard of the paper is low. K. Stewartson, England

2451. Miller, R. P., and Nemecek, I. V., Coefficients of discharge of short pipe orifices for incompressible flow at Reynolds numbers less than one, ASME Ann. Meet., New York, N. Y., Nov.-Dec. 1958. Pap. 58-A-106, 7 pp.

The object of this investigation was to determine the coefficient of discharge C_d to be used in the standard orifice formula $Q =$

$C_d A \sqrt{2gh}$, for computing the flow of incompressible fluids through short pipe orifices. Flow rates were restricted to the range of Reynolds numbers between 10^{-3} and 10^{-1}. Length-to-diameter ratios of the orifices were varied between 2 and 10. It was found that the coefficients of discharge can be expressed as a constant times the square root of Reynolds number, where the constant is a function of the length-to-diameter ratio of the orifice.

From authors' summary

2452. Adamov, G. A., Approximate calculation formulas for the coefficient of hydrodynamic resistance (in Russian), *Vestn. Inzh. i Tekhnikov* no. 2, 74-79, 1953; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10290.

Based on accurate formulas of a universal character deduced earlier by the author for the determination of the coefficient of resistance in a turbulent flow [G. A. Adamov, *Vestn. Inzh. i. Tekhnikov* no. 1, 1952] approximate graded formulas are recommended which are more convenient for calculations than the author's precise formulas, and guarantee the required degree of accuracy. A formula in the following form is proposed for the determination of λ of rough tubes when a condition of turbulent automodelling is present

$$\lambda = \frac{1}{4}\left(\lg \frac{7.41}{\epsilon}\right)^{-2} \qquad [1]$$

which for different ranges of variation of relative roughness ϵ and for the given degree of accuracy leads to a series of formulas having the form of

$$\lambda = C\epsilon^n \quad \text{or} \quad \lambda = C\frac{e_k^n}{D^n} \qquad [2]$$

where e_k is the equivalent (hydraulic) absolute roughness. From the determination of λ for smooth tubes the following equation is made use of

$$\frac{1}{\lambda^{1/2}} = 2 \lg \frac{R\lambda^{1/2}}{2.51} \qquad [3]$$

which, for different limits of variation of Reynolds number R, leads to a formula having the form of $\lambda = C/R^n$. A two-term approximate formula in a general form is also proposed. To conclude the study there is put forward a collated table giving the approximate graded formulas for the determination of λ, which, in the given range of changes of ϵ and R, guarantee the determined degree of calculation accuracy by comparison with formulas [1] and [3]. No comparison is given of the recommended formulas with the other known ones.

V. I. Gotovtsev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2453. Yablonskii, V. S., Analysis of some problems of pumping heated viscous liquids along pipe systems (in Russian), *Tr. Mosk. Neft. In-ta*, no. 17, 3-42, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10294.

Paper gives the results of three investigations made by the author in the field of the transport of heated viscous liquids in pipe systems: on the pumping operation, on the optimum temperature of the preheating and on the maintenance of the performance of the main petroleum pipe system at its optimum level. An analytical solution is put forward for the loss of pressure during the flow of the heated liquid along the pipe system, which makes it possible to determine pressure losses, showing extreme and boundary values for the losses for different, practically important cases. A general solution is proposed for the problem of the optimum temperature of the preheating at which the total consumption when pumping and heating up the liquid reaches a minimum. A description is given of a method for determining the most advantageous hydraulic and thermal parameters for pumping petroleum in pipe systems.

A. D. Al'tshul'

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2454. Dubinskii, M. G., Gas flow in straight-line ducts (in Russian), *Izv. Akad. Nauk SSSR Otd. Tekh. Nauk* no. 5, 110-112, May 1956.

2455. Dolmatov, K. I., Influence of a plane perpendicular to the axis of a tube on the compression coefficient of the tube (in Russian), *Tr. In-ta Matem. i Mekhan. Akad. Nauk UzSSR* no. 18, 73-78, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10253

An examination is made of the plane problem on the flow of an ideal incompressible liquid in a rectilinear slot, in front of which is situated an infinitely long wall perpendicular to the slot. The flow takes place with breaking away of the stream from the slot edges. In the absence of the wall the problem is that of the flow of liquid in a nozzle, postulated by Borda and solved by Helmholz in 1869. From the solution obtained, a formula is deduced for the compression coefficient of the stream, into which a parameter comes in, connected with the size of the distance of the wall from the edge of the slot in some correlation. It should be noted that to ensure greater clarity the word "tube" in the heading of the paper should be replaced by the word "slot."

G. N. Pyakhteev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2456. Griffith, P., Clark, J. A., and Rohsenow, W. M., Void volumes in subcooled boiling systems, ASME-AIChE Heat Transfer Conf., Chicago, Ill., Aug. 1958. Pap. 58-HT-19, 20 pp.

Photographs were taken of boiling at 500, 1000 and 1500 psia in a half-inch rectangular channel. Void fraction is determined by counting and measuring vapor bubbles and correlated versus heat input. Velocities were 20 and 30 fps, subcooling of 9 to 150 F and heat inputs of 0.25 to 2.70×10^6 Btu/hr-sq ft. A simple but noteworthy analysis correlates only fairly with authors' data, but fairly well with the high-velocity high heat input data at 2000 psia of Egan, Dingee and Chastain [ASME Paper 57-A-74]. The analysis assumes the heat input equal to the heat of condensation of the bubbles (high heat input) and evaluates the latter by approximating the condensing area in terms of the thermal layer thickness. The resulting void fraction is proportional to the heat input rate, while authors' data is closer to a second-power dependance. Writer believes that the derived expression for void fraction as a function of length (or quality) might possibly fit a wider range of heat inputs if the assumptions for condensing area were revised accordingly.

M. A. Santalo, Mexico

2457. Sandberg, C. R., and Gournay, L. S., The effect of fluid-flow rate and viscosity on laboratory determinations of oil-water relative permeabilities, *J. Petr. Technol.* **10**, 2, 36-43, Feb. 1958.

The effect of fluid-flow rate and fluid viscosity on oil-water relative permeability determinations was studied using the "dynamic flow technique." In this work relative permeability curves were obtained for homogeneous small core samples from several sandstone outcrop formations. Radio-tracers were used for the determination of fluid saturation and for the detection of saturation gradients. Cobalt-60 in the form of cobaltous chloride was used as a water-phase tracer in some of the experiments. Iodine-131 in the form of iodobenzene and Mercury-203 in the form of mercury diphenyl were used as oil-phase tracers in other experiments. Flow rates for each phase were varied within a range of 2.5 to 140.6 ml/hr. Oil-phase viscosities under flowing conditions were varied from 0.398 to 1.683 cp.

The relative permeabilities obtained were found to be solely a function of saturation and independent of flow rate, provided there

was no saturation gradient induced in the core sample by "boundary effect." Even though equilibrium with respect to flowing conditions was obtained at the lower flow rates, where a saturation gradient exists, this equilibrium is of a "contingent"-type rather than the "steady-state" equilibrium implicit in the relative permeability concept. The only effect of increasing the oil or non-wetting phase viscosity was to decrease the flow rate required for the elimination of the boundary effect.

Fairly good agreement between experimentally determined and calculated values of the boundary effect was obtained when the non-wetting oil phase was the only flowing phase.

From authors' summary

2458. Melikyan, R. A., The hydrodynamic conditions present when a gas floats up through a layer of liquid (in Russian), *Zh. Prikl. Khim.* **30**, 1, 38-44, 1957; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10267.

When a gas floats up through a layer of liquid, various conditions of flow make their appearance (bubbling, foaming, wavy, etc.) depending on the volume of gas released. Qualitative descriptions of these regimes are given and also some elementary concepts in regard to the establishment of this or that regime in relation to the volume of gas released and the height of the layer of liquid. G. A. Tirskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2459. Kozlov, B. K., Conditions and forms of motion of an air-water mixture in a vertical pipe (in Russian), Gidrodinamika i teploobmen pri kipenii v kotlakh vysokogo davleniya, Moscow, Akad. Nauk SSSR, 1955; 11-20; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4456.

When describing air-water elevators it is customary to distinguish the characteristic conditions of optimum working and maximum air supply. In addition, author distinguishes conditions of beginning and ending the air supply; the determination of these conditions is purely formal and the concepts introduced are not used to reach any conclusions. For generally assumed conditions an example is given of the empirical relationships between the volume flow gas content and the Froude number which can be plotted on the basis of treatment of the results of the measurements made on an actual elevator.

A description is given of the structure of an air-water mixture in its flow in vertical pipes and also of the empirical relationships which determine the conditions of occurrence of differing structures. V. A. Arkhangel'skii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2460. Litvinenko, A. M., Measurement of the density of hydraulic mixtures pumped through tubes of 200-300 mm diameter (in Russian), Avtoref. diss. kand. tekh. nauk, Vses. n.-i. in-t Zh.-d. str.-va i proektirovaniya (Thesis, All-Sov. Sci. Res. Inst. Rly Constr. & Design) Moscow, 1956; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3271.

2461. Perel'man, B. G., Discharge of liquid through an outlet with a baffle placed in front of it (in Russian), *Tr. Mosk. Aviats. In-ta* no. 74, 145-146, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10303.

A curve is produced to show the relation between the discharge coefficient and the relative diameter of the baffle when liquid is flowing out of a round hole in the bottom of a reservoir, when a baffle-plate is placed before the outlet. P. G. Kiselev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2462. Watson, J., A solution of the Navier-Stokes equations illustrating the response of a laminar boundary layer to a given change in the external stream velocity, *Quart. J. Mech. Appl. Math.* **11**, 3, 302-325, Aug. 1958.

Consideration is given to the unsteady flow of an incompressible, viscous fluid over a doubly-infinite plane. The free-stream velocity varies with time, while the plane is stationary. The following characteristics are assigned to the flow: (1) the parallel velocity component u is independent of position along the plane, (2) the normal velocity component is constant with time and with position throughout the entire flow field; in particular, admitting a steady suction at the plane surface. Study is made of three particular cases of the general solution: (1) impulsive change of the free-stream velocity from one steady value to another; (2) uniform acceleration of the free stream starting from a steady value; (3) a decaying oscillation superposed on a steady (mean) free-stream velocity. For each situation, formulas are derived and discussed for the velocity distribution, displacement thickness, and skin friction. Treatment is highly mathematical.

E. M. Sparrow, USA

2463. Payne, R. B., Calculations of unsteady viscous flow past a circular cylinder, *J. Fluid Mech.* **4**, 1, 81-86, May 1958.

Two-dimensional starting flow of a viscous fluid moving perpendicular to the axis of a circular cylinder at Reynolds numbers 40 and 100 is investigated. Calculations are made with the step-by-step integration of Helmholtz's vorticity equation.

Vorticity generated at the cylinder is transported round toward the rear stagnation point and originates two eddies attached to the rear of the cylinder; these increase in size with time. Vorticity is spread over a larger area for $R = 40$ than for $R = 100$.

Drag coefficient at $R = 40$ increases rapidly from 3.00, initially, to about 1.6177 calculated for the steady flow at $t = 6$. At $R = 100$ the drag on the cylinder decreases from 1.20, initially, to a minimum of 1.00, then rises to 1.10 at $t = 3$. G. Noseda, Italy

2464. Vasil'ev, O. F., Application of the theory of vortex motion to the problem of orifice flow with formation of an air funnel (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 3, 108-114, Mar. 1957.

When a liquid flows out of a basin with free surface a vortex funnel is generally formed. Author investigates this phenomenon for a basin of infinite extension and with an orifice in the horizontal bottom, the height of the liquid surface being H. It is assumed that the problem is of rotational symmetry and that the flow is inviscid but of nonvanishing curl. By using a Fourier expansion the partial differential equation of the problem is transformed into an ordinary one. The latter can be solved by Bessel functions. The results for the velocity components, calculated for nonvanishing curl, are compared with results for irrotational flow. Author also gives another form of the solution using the method of infinite integrals. W. Wuest, Germany

2465. Kochenov, I. S., On unsteady motion of fluids in a heated tube (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **107**, 5, 689-692, Apr. 1956.

Compressible Flow (Continuum and Noncontinuum Flow)

(See also Revs. 2497, 2498, 2515, 2543, 2554, 2555, 2556, 2560, 2568, 2599, 2600, 2603, 2604, 2605, 2606, 2607, 2610, 2657, 2658, 2663, 2677)

2466. Landahl, M. T., Theoretical studies of unsteady transonic flow. I. Linearization of the equations of motion (in English), *Flygtekn. Försöksanst. Medd.* no. 77, 18 pp., 1958.

Mathematical paper considers, on a general physical basis, the requirements for linearization of equations. In essential agree-

ment with earlier work it is found that the reduced frequency k must be much greater than the largest departure of the local Mach number from unity in the flow. The slow-moving (receding) waves then have a wave length λ_y small in comparison with reference length of body. Some properties of the nonlinear transonic solution are discussed and the linearized transonic solution with $\lambda_y \to 0$ (unlike the acoustical solution) is shown to exhibit those properties correctly.

From author's summary by D. C. Pack, Scotland

2467. Mugler, J. P., Jr., Basic pressure measurements at transonic speeds on a thin 45° sweptback highly tapered wing with systematic spanwise twist variations—untwisted wing, *NASA Memo* 10-20-58L, 7 pp. + 7 tables + 5 figs., Dec. 1958.

Data are presented which were obtained in the Langley 8-foot transonic pressure tunnel at Mach numbers from 0.800 to 1.200 through an angle-of-attack range from −4° to 12°. The wing has a taper ratio of 0.15 and an aspect ratio of 4.0. The wing is cambered and has a thickened root section. Data were taken at stagnation pressures of both 1.0 and 0.5 atmosphere.

From author's summary

2468. Mahony, J. J., The internal flow problem in axi-symmetric supersonic flow, *Comm. Aero. Res. Lab. Melbourne, Austral., Rep.* A. 101, 38 pp. + 3 figs., Jan. 1957.

Author considers the possibility of obtaining a linearized solution for the problem of internal flow in a duct where discontinuities in the wall cause ordinary linear theory to fail. Using characteristic variables author establishes at first a set of integral equations for the exact nonlinear problem. Assuming only small variations in the shape of the wall this set of integral equations can be approximated by a set of linear first-order partial differential equations on characteristic coördinates.

With a known solution of these linear equations the mapping functions for the characteristic variables on the space coordinates can be obtained again by a set of integral equations, for which also a uniformly valid first approximation can be found. Although an exact proof of the validity is not given, it is apparently plausible that the method is correct. Some solution methods for the linear equation (reduction to Euler Darboux-Poisson equation) are discussed. Method is applied to problem of expanding jet, and gives a complete first-order result for this flow. Behavior of an expansion discontinuity in the slope of the wall of a duct is shown to correspond to finite velocity and velocity gradients on corresponding Mach lines but to a shock wave in the reflection of these Mach lines.

R. Timman, Holland

2469. Dombrovskii, G. A., Approximate solution for basic boundary problems of plane, supersonic, steady, potential motion of gas (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **107,** 6, 799-802, Apr. 1956.

Approximation used consists in replacing coefficient appearing in the symmetric form of Chaplygin's equations by the function $K = -(ntgmt)$.[4] This is equivalent to replacing the adiabatic curve by an approximating one. Owing to the suitable form of K, Chaplygin's equations can be integrated in closed form. General expressions for velocity potential and stream function are given. Application to the four basic boundary problems is discussed, i.e. when (1) the curve is not characteristic, (2) two characteristic curves cross each other, (3) the characteristic curve crosses a free streamline, (4) the characteristic curve crosses a rigid wall.

W. Prosnak, Poland

2470. Clarke, J. F., Energy transfer through a dissociated diatomic gas in Couette flow, *J. Fluid Mech.* **4,** 5, 441-465, Sept. 1958.

The transfer of energy through a dissociated diatomic gas in Couette flow is considered, taking oxygen as a numerical example. The two extremes of chemical equilibrium flow and chemically frozen flow are dealt with in detail, and it is shown that the surface reaction rate is of prime importance in the latter case. The chemical rate equations in the gas phase are used to estimate the probable chemical state of the gas mixture, this being deduced from the ratio of a characteristic chemical reaction time to a characteristic time for atom diffusion across the layer. The influence of the surface reaction appears to spread outwards through the flow from the wall as gas-phase chemical reaction times decrease. For practical values of the surface reaction rate on a metallic wall, the energy transfer rate may be significantly lower in chemically frozen flow than in chemical equilibrium flow under otherwise similar circumstances.

Similar phenomena to those discussed will arise in the more complicated case of boundary-layer flows, so that a treatment of the simpler type of shear layer represented by Couette flow may be of some value in assessing the relative importance of the various parameters.

From author's summary by S. S. Penner, USA

2471. Cheng., H. K., Similitude of hypersonic flows over thin and slender bodies—an extension to real gases, AFOSR TN 58-87 (Cornell Aero. Lab. Rep. AD-1052-A-6; ASTIA AD 148 136), 13 pp. + 6 figs., Feb. 1958.

On the basis of the governing equations and boundary conditions, similitude in the hypersonic inviscid flow fields over thin or slender bodies is examined, wherein the restriction to ideal gas with constant specific heats is removed.

When local thermal (vibrational and chemical, etc.) equilibrium prevails, i.e. when the properties of gas are determined nearly by the thermodynamic properties corresponding to the local pressure and temperature (or density), the parameter $M_\infty\tau$ of Tsien and Hayes remains the controlling parameter for the similar fields of hypersonic flows past thin or slender bodies. However, general correlation of similar flows of real gases are possible only between flows under the same free-stream atmosphere, i.e. with the same p_∞, ρ_∞ (or T_∞) and initial gas composition, say $(X_i)_\infty$'s. Examples of correlation are given for flows of real gases over wedges.

From author's summary

2472. Fox, P., and Ralston, A., On the numerical solution of the equations for spherical waves of finite amplitude. I, *J. Math. Phys.* **36,** 4, 313-328, Jan. 1958.

Authors have considered the numerical solution of the equations for spherical waves of finite amplitude. The compressed sphere of gas under consideration has a maximum density at its center of three times atmospheric density, which corresponds to quite a mild explosion. It has been shown that in the region covered by calculations there is no discernible shock. The second outward going wave has been shown to be very weak, such that no discernible second inward wave forms. These results are in contrast to Unwin's [*Proc. Roy. Soc. Lond.* (*A*) **178** (1941)] calculations of strength of recoil waves, which suggested the possibility of the formation of a shock toward the center of the sphere.

G. S. Verma, USA

2473. Roberts, L., On the numerical solution of the equations for spherical waves of finite amplitude—II, *J. Math. Phys.* **36,** 4, 329-337, Jan. 1958.

Following the procedure outlined by Lax [*Comm. Pure Appl. Math.* **7,** p. 159, 1954] for the computation of compressible flows, author considers the free expansion of a sphere of compressed gas into the atmosphere and has shown that there is no shock even for the stronger initial density distribution, say, for the compression ratio 6:1. He has tried to improve the solutions in the regions of expansion by extrapolation procedure.

G. S. Verma, USA

2474. Betchov, R., Nonlinear oscillations of a column of gas, *Phys. Fluids* **1**, 3, 205–212, May-June 1958.

Several authors studied experimentally the motion of a column of air in a long pipe, closed at one end and driven at the other by an oscillating piston. At resonance they observed shock waves travelling in the tube. Paper presents a simple theoretical analysis of the motion, based on discontinuous linearized solutions and a secular equation. This equation guarantees that the motion remains periodic in spite of the cumulative effects of the nonlinear terms. For an inviscid gas, the amplitude at resonance is found to be finite and to be determined by nonlinear effects. Friction can be taken into account and is included in the final results, which are presented in the form of a chart. The results obtained may have applications in the fields of transonic flutter, jet pulsations, and magnetohydrodynamics.

From author's summary by G. Sestini, Italy

2475. Chernyi, G. G., Perfect gas flows around bodies at hypersonic velocities (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 6, 77–85, June 1957.

Writer considers the plane and axially symmetrical flow of an ideal gas around bodies at higher Mach numbers. The method of attack applies the representation of the dependent functions in the dynamic equations of gasdynamics in terms of a power series in $\varepsilon = (\gamma - 1)/(\gamma + 1)$. The elements considered are wedge, cone, and general axially symmetric bodies. Special attention is attached to the calculation of the wave-drag coefficient. The variation of the entropy in the direction normal to the stream surfaces is included. The procedure involves simple gasdynamics equations and results are illustrated by means of numerous graphs. Some diagrams are compared with the Kopal tables of supersonic flow around cones.

M. Z. v. Krzywoblocki, USA

2476. Grodzovskii, G. L., Some peculiarities of flow around bodies at hypersonic velocities (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 6, 86–92, June 1957.

Writer discusses some peculiar features of a flow around bodies when the Mach number goes to infinity. He uses the equations of the classical gas-dynamics with the limiting value of M. Particular attention is attached to the wave drag in two cases: plane and axially symmetrical motions. The results are presented in form of diagrams of the pressure ratio as a function of the coordinate x, etc. The notion of the wave-drag coefficient of the optimum body is used as a comparison factor. M. Z. v. Krzywoblocki, USA

2477. Wood, G. P., Calculations of the rate of thermal dissociation of air behind normal shock waves at Mach numbers of 10, 12 and 14, *NACA TN* 3634, 34 pp. + 3 tables + 2 figs., Apr. 1956.

Simple collision theory is used to calculate dissociation and recombination rates. Thoughtful use of literature is made to select reasonable values of the many poorly known quantities. Calculated equilibrium constants for nitrogen and oxygen are within order of magnitude of those previously obtained from spectroscopic data. Dissociation is assumed to take place in two separate steps starting at point where vibration is completely excited. First, oxygen dissociates to equilibrium, then nitrogen. Main limitation on numerical computations is that recombination is neglected. Consequently, partial dissociation equilibrium conditions cannot be found, but results can be put in form independent of initial density. Results given are pressure, density, temperature, and concentration as functions of product of initial O_2 concentration and time at $M_1 = 10$, 12, 14, and $T_1 = 300$ K. Extrapolated equilibrium conditions for O_2 dissociation are obtained only at $M_1 = 14$; therefore, this is only computation of nitrogen dissociation presented. Result found is that nitrogen dissociation occurs too slowly to affect air properties within length of any reasonable vehicle. L. Mack, USA

2478. Rogers, M. H., Similarity flows behind strong shock waves, *Quart. J. Mech. Appl. Math.* **11**, 4, 411–422, Nov. 1958.

Similarity solutions describing the flow of a perfect gas behind strong shock waves are investigated for the three cases of plane, cylindrical, and spherical symmetry. The flow is caused by an expanding piston, and the total energy increases as a power of time. The ratio of kinetic to internal heat energy of the gas is computed and it is found that in the case of a piston which is expanding at a uniform rate there is equipartition of energy.

From author's summary by L. Trilling, USA

2479. Tidman, D. A., Structure of a shock wave in fully ionized hydrogen, *Phys. Rev.* (2) **111**, 6, 1439–1446, Sept. 1958.

The structure of a shock wave in fully ionized hydrogen is examined theoretically. Author starts with the Fokker-Planck equation and, following the analysis of Mott-Smith for a neutral gas, uses a bimodal, time-independent, distribution function for the protons in the interior of the shock. The electrons are assumed to be in equilibrium locally among themselves but are not necessarily in equilibrium with the protons.

The proton shock thickness (l), the length (l_e) in which electrons reach thermal equilibrium with the protons, and the characteristic length (l_v) over which stream velocity differences between protons and electrons disappear, have been computed as a function of Mach number (M). The proton shock thickness l is very large for $M \simeq 1$, decreases at first with increasing M, and finally increases as M^4 for large M. The variation of l with M can be understood in terms of the assumed bimodal distribution function. The length l_e is larger than l except for $M \simeq 1$. For all values of M, $l_v \ll l$ or l_e. S. S. Penner, USA

2480. Bennett, F. D., Cylindrical shock waves from exploding wires, *Phys. Fluids* **1**, 4, 347–352, July-Aug. 1958.

Technique is presented for rendering visible the cylindrical shock waves produced by electrically exploding a fine wire. Rotating mirror enables recording of a distance-time plot of cross section of disturbance, which includes luminous particle paths and possible shock-wave trajectories. A small, plane mirror is placed just behind the wire, perpendicular to axis of optical system, so that reflected image of explosion coincides with disturbance itself when seen through slit by camera lens. Photographs disclose separation of shock wave from luminous contact surface, after about 1 μ sec. Comparison of recorded results with calculations of S. C. Lin [AMR **7** (1954), Rev. 2529] of law of variation of radius of wave with time shows good agreement after 1 μ sec. Author states that the initial disagreement is due to the fact that wave is still receiving appreciable amounts of energy from wire explosion. Author points out the fact that contact surface increases following some parabolic law, similar to that of shock wave, although there is as yet no known explanation for this behavior. A. Balloffet, USA

2481. Hammitt, A. G., The interaction of shock waves and turbulent boundary layers, *J. Aero. Sci.* **25**, 6, 345–356, June 1958.

The boundary-layer analysis employs average parameters, f and k, similar to those used by Crocco and Lees [AMR **6** (1953), Rev. 1676]. The pressure ratios for separation on a straight wall are calculated. For the same $f - k$ relation, it is possible to obtain much higher pressure ratios with an incident-reflected shock than the separation pressure ratio associated with a single shock. This result is consistent with experimental observations.

G. E. Nitzberg, USA

2482. Chang, C. T., On unsteady interaction between a weak thermal layer and a strong plane oblique shock, *J. Aero. Sci.* **25**, 5, 317–323, May 1958.

Paper investigates theoretically an unsteady interaction between a weak upstream temperature disturbance and a plane shock gen-

erated by a concave corner in a wall. Temperature disturbance is taken as a layer of hot gas of uniform temperature whose wave front is inclined at a constant angle to the undisturbed flow.

It is found that, even for a weak disturbance, the flow downstream of the shock is usually mixed; the motion being supersonic outside, and subsonic inside, a sonic circle. The qualitative nature of the downstream flow is described. It is computed by using the method of characteristics in the supersonic region, and, in the subsonic region, a method similar to that adopted by Lighthill for studying the diffraction of blast waves.

D. W. Holder, England

2483. Boyer, D. W., Brode, H. L., Glass, I. I., and Hall, J. G., Blast from a pressurized sphere, *Univ. Toronto Inst. Aerophys. Rep.* 48, 33 pp. + 1 table + 61 figs., Jan. 1958.

Some experimental results are presented of the spherical flow generated by the shattering of 1-, 2-, and 5-inch diameter glass spheres initially filled with air, helium, or sulphur hexafluoride at pressures up to 22 atmospheres. Radius-time plane drum-camera schlieren photographs are presented of the blasts from all spheres as well as time sequence spark-shadowgraph pictures of the blast from the 2-inch diameter air spheres. The experimental results show the technique to be suitable for the production and study of spherical flows under readily controlled laboratory conditions. Numerical solutions are given for the variation of all flow quantities, as functions of time and space, for the 2-inch diameter air and helium sphere cases. Schlieren photographs of the corresponding experimental blasts are in good qualitative agreement with the theoretical wave diagrams and a quantitative comparison of the 2-inch diameter air sphere blast with theory shows fair agreement.

From authors' summary

2484. Chernyi, G. G., Adiabatic motions of a perfect gas with strong shock waves. One-dimensional nonstationary flows (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 3, 66–81, Mar. 1957.

A considerable amount of work was devoted to problems of motion of a gas with shock waves in one-dimensional nonsteady, plane and axisymmetrical steady flows. Writer attacks the problem of a one-dimensional nonsteady flow of a gas with strong shock waves. The solution of the equation of motion is expressed by means of a power series in $\epsilon = (\gamma - 1)/(\gamma + 1)$. Numerous diagrams of pressure-density and velocity ratios illustrate the results. Numerical examples cover the range of Mach number up to infinity. This method was used by the author in his previous papers on the subject: "Flow around bodies of a gas of very high velocity," *Dokaldi Akad. Nauk SSSR* **107**, no. 2, 1956; and "One-dimensional unsteady motion of a gas with shock waves of strong intensity," ibid, **107**, no. 5, 1956.

M. Z. v. Krzywoblocki, USA

2485. Yang, H.-T., Reduction of Ikenberry-Truesdell equations to Burnett equations for slip flow, *J. Aero. Sci.* **25**, 6, 404–405 (Readers' Forum), June 1958.

Paper concerns equations of fluid dynamics according to molecular theory of gases. Navier-Stokes equations, which contain only first powers of the coefficient of dynamic viscosity μ are generally regarded as first approximations to these equations. Author shows that to second powers of μ the expressions for the stress tensor and for the heat flux in Ikenberry and Truesdell's paper [*J. Rat. Mech. Anal.* **5**, 1, 1–54, Jan. 1956] can be reduced to the corresponding Burnett expressions. It is mentioned that the Grad thirteen-moment equations can also be shown to include the Burnett expressions. Author therefore concludes that the Burnett equations may be considered as an approximation to the Ikenberry-Truesdell equations and to the Grad equations, and that the latter two systems may hence be better fitted to describe the slip flow regime (in rarefied gases) than the Burnett equations.

M. Morduchow, USA

2486. Kapur, J. N., Transverse component of velocity in a plane symmetrical jet of a compressible fluid, *Quart. J. Mech. Appl. Math.* **11**, 4, 423–426, Nov. 1958.

In the present paper, the transverse component of the velocity in the laminar motion of a plane symmetrical jet of a compressible fluid has been found, and its variation with respect to the distance from the jet axis has been studied.

From author's summary by L. Trilling, USA

2487. Ehlers, F. E., and Strand, T., The flow of a supersonic jet in a supersonic stream at an angle of attack, *J. Aero/Space Sci.* **25**, 8, 497–506, Aug. 1958.

Paper presents a solution of the linearized equations for flow induced by a supersonic jet at a small angle of attack in a supersonic stream, using Laplace transform. Solutions in two dimensions and three dimensions are obtained and results are compared to the work of other investigators, particularly Ward and Pack.

For the two-dimensional jet a parameter k measures reflection of waves from jet boundary. For $k > 1$ and zero angle of attack the jet boundary oscillates between positive and negative slope moving downstream. For $k < 1$ the slope decreases monotonically.

The symmetrical three-dimensional jet also has boundary with oscillating slope, and the perturbation due to angle of attack shows a waviness.

R. K. Sherburne, USA

2488. Abramovich, G. N., Turbulent jets in a moving medium (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 6, 93–101, June 1957.

Writer attacks the problem of a turbulent subsonic jet in a moving medium. He uses the most simple analysis of jets based upon the cross-sectional momentum integrals and energy integrals (analogous to Betz's method of calculating the drag) without solving any partial differential equations. As a fundamental parameter m he uses the ratio of the velocity of the external medium to the jet velocity at the opening. The results are presented in the forms of diagrams: width of a jet, ratio of the velocity in the jet to the maximum velocity on the axis of symmetry, temperature pattern, for plane and axially symmetrical jets as functions of M. The agreement with test data is good.

M. Z. v. Krzywoblocki, USA

2489. Dailey, C. L., A simplified universal rule for subcritical drag of a supersonic diffuser, *J. Aero/Space Sci.* **25**, 7, 470–471 (Readers' Forum), July 1958.

Author obtains the subcritical additive drag over arbitrary inlets by developing the momentum integral equations for the spilled flow. The resultant equation can be used for additive drag determinations if the shock flow pattern is obtained separately.

For simplified (pitot-type) inlets author's theory is compared to experimental data in Fig. 2 of the paper. No details are given to allow an evaluation of author's theoretical curve, and reviewer was unable to match experimental data shown in Fig. 2 with the original sources quoted. Possible improvements of the proposed theory over previous methods can therefore not be evaluated.

F. Landis, USA

Boundary Layer

(See also Revs. 2312, 2462, 2463, 2477, 2481, 2501, 2556, 2557, 2573, 2602, 2613, 2618, 2664)

2490. Hansen, A. G., On possible similarity solutions for three-dimensional incompressible laminar boundary-layer flows over developable surfaces and with proportional mainstream velocity components, *NACA TM* 1437, 77 pp. + 2 figs., Sept. 1958.

Author seeks similarity solutions (separation of variables) by studying boundary-layer equations in their most general, orthogonal curvilinear coordinate form. Possibilities and restrictions are revealed. In some cases where similar solutions are revealed two simultaneous equations must be solved to obtain all components of flow. Author studies problem of uncoupling these equations so that each can be solved singly. While not much new regarding possible types of similar flows is found, the article is clear and unified and reviewer believes it to be most comprehensive treatise on the problem now available. Work was originally done as Ph. D. thesis. A. M. O. Smith, USA

2491. Tetervin, N., Theoretical distribution of laminar-boundary-layer thickness, boundary-layer Reynolds number and stability limit, and roughness Reynolds number for a sphere and disk in incompressible flow, *NACA TN* 4350, 23 pp. + 13 figs., Sept. 1958.

The laminar-boundary-layer thickness, the boundary-layer Reynolds number and minimum critical Reynolds number, and the roughness Reynolds number have been calculated by an approximate method for a sphere and disk in the supercritical Reynolds number region. The calculations for the sphere show that the boundary layer at the stagnation point of a sphere is much thicker than that on an airfoil, that the boundary-layer thickness increases very slowly with an increase in distance from the stagnation point, that the boundary layer over the forward portion of a sphere is highly stable at large Reynolds numbers with respect to the Tollmien-Schlichting type of waves, and that roughness of a given height produces the largest roughness Reynolds numbers at about 57° from the stagnation point. The calculations for the disk show the unusual result that the boundary-layer thickness is greatest at the stagnation point and decreases with an increase in distance from this point, that the boundary layer is extremely stable with respect to the Tollmien-Schlichting type of waves, and that roughness of a given height produces a given roughness Reynolds number over a smaller portion of the disk surface than over the sphere surface.

From author's summary by S. Corrsin, USA

2492. Yang, K.-T., On certain similar solutions to unsteady laminar boundary-layer equations in low-speed flow, *J. Aero/Space Sci.* **25,** 7, 471–472 (Readers' Forum), July 1958.

Author provides definition of variables which yield similitude (homology) solutions for cases of: unsteady, two-dimensional compressible boundary layer including suction or blowing; incompressible, unsteady flow over a blunt-nosed axially symmetric body. Numerical solutions are not presented; author states they are under preparation. S. J. Kline, USA

2493. Voronin, V. I., Calculations for the laminar boundary layer on bodies of rotation in a compressible gas (in Russian), *Tr. Voronezhsk. In-ta* **42,** 2, 11–12, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10458.

A generalization is given of the Loitsianskii-Dorodnitsyn method for calculating the laminar boundary layer for the case of bodies of rotation, assuming the existence of a the. ally insulated wall. E. I. Obroskova

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2494. Mirels, H., Relative importance of free-stream vorticity and self-induced pressure gradient on a flat-plate boundary layer *J. Aero/Space Sci.* **25,** 5, 339–340 (Readers' Forum), May 1958.

2495. Konstantinov, N. N., Comparative investigation of friction stress on the surface of a body (in Russian), *Tr. Leninger. Politekhn. In-ta* no. 176, 201–213, 1955; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10748.

Preliminary results are published of experiments on the measurement of friction stress in the turbulent boundary layer, carried out by different methods, namely: (1) the diffusion method; (2) the fall of pressure on the boundary strip, placed normally to the wall; (3) surface tubes; (4) the theory of impulses, analytically. Good convergence was noted with the readings of the diffusion transmitter and the boundary slip (corner), whereas the coincidence with the readings of the surface tubes was somewhat worse. The experimental data obtained were used by the author to verify the method of calculation of the turbulent boundary layer proposed by L. G. Loitsianskii. V. N. Kaloshnik

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2496. Shestopalov, V. P., General solution for the problem of the thermal boundary layer in a diffuser (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 8, 3–9, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10459.

It is shown that the solution for the thermal boundary layer for an incompressible flow in the diffuser will be in a final form if the wall temperature is represented by a resolution in reverse steps of x (x being the distance along the wall of the diffuser); in so doing use is made of the known solution for the dynamic boundary layer in the diffuser [see Kochin, Kibel', Roze, *Gidromekhanika*, T.2]. The solution for the temperature is recorded by means of hypergeometrical series, which, as the calculations show, are in good agreement. An expression is deduced for Nusselt number N, depending on the angle of inclination of the walls of the diffuser; it is shown that the N of the diffuser may differ by more than X 2 from the N of the plate.

E. I. Obroskova

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2497. Le Fur, B., Calculation of the laminar boundary layer in compressible flow with pressure gradient along an insulated wall (in French), *C. R. Acad. Sci. Paris* **246,** 4, 546–548, Jan. 1958.

The problem of the compressible boundary-layer flow with variable density ρ and viscosity μ and a Prandtl number $Pr \neq 1$ is reduced to the problem of a boundary-layer flow with constant ρ and μ by a transformation which is a generalization of the Howarth-Stewartson transformation. The new transformation involves the recovery factor r. By this transformation the momentum equation for compressible boundary-layer flow can be reduced to the momentum equation for incompressible flow. The temperature profile is assumed to be a fourth-order polynomial in y (coordinate normal to the wall in the incompressible problem). Author states that for the flat plate flow his results agree with those of Chapman and Rubesin. No comment is made about the determination of r for the general case (pressure distribution along the wall).

Irmgard Flugge-Lotz, USA

2498. Demetriades, A., An experimental investigation of the stability of the hypersonic laminar boundary layer, Guggenheim Aero. Lab., Calif. Inst. Tech. Memo. 43, 45 pp. + 4 tables + 34 figs., May 1958.

An experimental investigation of the stability of the hypersonic laminar boundary layer was carried out for the case of a flat insulated surface at zero angle of attack. The streamwise amplitude variation of both "natural" disturbances (i.e., flow fluctuations existing naturally in the boundary layer) and of disturbances artificially excited with a "siren" mechanism was studied with the aid of a hot-wire anemometer. In both cases it was found that such small fluctuations amplify for certain ranges of the fluctuation frequency and the Reynolds number R_δ, and damp for others. The demarcation boundaries for the amplification (instability) zone were found to resemble the corresponding boundaries of boundary-layer instability at lower speeds. A "line of maximum

amplification" of disturbances was also found. The amplification rates and hence the degree of "selectivity" of the hypersonic layer were found, however, to be considerably lower than those at the lower speeds. The disturbances selected by the layer for maximum amplification have a wave length estimated at about twenty times the boundary-layer thickness δ, which is appreciably longer than the corresponding wave lengths for low-speed boundary-layer flow. From author's summary

2499. Braslow, A. L., and Knox, E. C., Simplified method for determination of critical height of distributed roughness particles for boundary-layer transition at Mach numbers from 0 to 5, *NACA TN* 4363, 9 pp. + 5 figs., Sept. 1958.

In previous investigations a correlation of the minimum roughness particle size required to initiate transition has been accomplished [*NACA TN* 3858 and *RM* L58A17]. Roughness particles smaller than the critical size have been found to introduce no disturbances of sufficient magnitude to influence transition, whereas roughness particles equal to the critical size initiate the formation of turbulent spots at the roughness that coalesce into a continuously turbulent flow somewhat downstream of the roughness.

In the present paper a simplified method has been devised for determination of the critical height of three-dimensional roughness particles required to promote premature transition of a laminar boundary layer on models of airplanes or airplane components in a wind tunnel with zero heat transfer. A single equation is derived which relates the roughness height to a Reynolds number based on the roughness height and on local flow conditions at the height of the roughness, and charts are presented from which the critical roughness height can be easily obtained for Mach numbers from 0 to 5. A discussion of the use of these charts is presented with consideration of various model configurations. The method has been applied to various types of configurations in several wind-tunnel investigations conducted by the National Advisory Committee for Aeronautics at Mach numbers up to 4, and in all cases the calculated roughness height caused premature boundary-layer transition for the range of test conditions.

From authors' summary by M. H. Bertram, USA

2500. Henshall, B. D., and Cash, R. F., An experimental investigation of leading-edge flow separation from a 4 per cent thick two-dimensional biconvex aerofoil, *Aero. Res. Counc. Lond. Rep. Mem.* 3091, 4 pp. + 23 figs., 1958.

The development of leading-edge flow separation as incidence is raised, for a 4% thick two-dimensional biconvex airfoil, was studied experimentally for wide ranges of incidence at Mach numbers of 0.40, 0.50, 0.60 and 0.70. Pressure distributions and flow photographs are presented which illustrate the growth of the "bubble" of separated flow. From authors' summary

2501. Stewartson, K., On Goldstein's theory of laminar separation, *Quart. J. Mech. Appl. Math.* **11,** 4, 399–410, Nov. 1958.

It is shown that the expansion assumed by Goldstein to describe the flow near separation in a laminar boundary layer is incomplete and that further terms which include powers of logarithms must be added. These terms are individually singular at separation. Although it cannot be inferred that the velocity profile must also be singular at separation, it is suggested that if the boundary layer is to continue downstream of separation the main stream must adjust itself so that these terms cannot appear. The solution may then be continued through separation by means of a power series into a region of reversed flow. However, it is shown that in addition to the power series an infinity of new terms may appear in the solution downstream of separation which is therefore no longer specified uniquely by the mainstream velocity and the velocity profile at the beginning of the boundary layer.

From author's summary by J. C. Rotta, Germany

2502. Stuart, J. W., Jr., Low-drag specification of surface irregularities, AFOSR TN 58-404 (Univ. So. Calif. Engng. Center Rep. 40-203; ASTIA AD 158 207), 10 pp. + 3 figs., Mar. 1958.

By a re-interpretation of the experimental results on boundary-layer transition by Tani and Dryden readily usable nomographs are obtained which can be utilized for engineering purposes.

From author's summary

2503. Foote, J. R., Flow against a vertical plate with large suction, *J. Aero/Space Sci.* **25,** 7, 462–463 (Readers' Forum), July 1958.

2504. Gregory, N., and Walker, W. S., Experiments on the use of suction through perforated strips for maintaining laminar flow: transition and drag measurements, *Aero. Res. Counc. Lond. Rep. Mem.* 3083, 12 pp. + 12 tables + 23 figs., 1958.

Wind-tunnel tests are described in which suction is applied at perforated strips, as an alternative to porous strips or slots, in order to maintain a laminar boundary layer. A test was first carried out on a single row of perforations on a cambered plate as a preliminary to the main tests which were performed on strips of multiple rows of perforations drilled through the surface of a low-drag-type airfoil 13% thick and of 5-ft chord.

Up to a wind speed of 180 fps it has been ascertained that suction may be safely applied to extend laminar flow provided the ratio of hole diameter to boundary-layer displacement thickness is less than 2, the ratio of hole pitch to diameter is less than 3 and there are at least three rows of holes in the strip. With less than three rows, the criteria are much more restrictive. It is possible to extend laminar flow by suction through perforations whose diameters and pitches exceed these values slightly, but only with the risk that excessive suction quantities will produce wedges of turbulent boundary layer originating at the holes.

A uniform distribution of suction through the holes was necessary. This was successfully obtained by two methods, the use of cells and throttle holes, and with tapered holes. In particular, tests were carried out on some panels in which the cells and tapered holes had been constructed by commercial methods, and the suction distribution proved satisfactory.

The resistance of some of the cellular arrangements was measured. It was found that, when the suction quantities were the minimum required to maintain laminar flow, the additional losses in total head of the sucked air due to the resistance of the throttle holes could be made small compared with the loss in total head of the sucked boundary layer. From authors' summary

2505. Greber, I., Hakkinen, R. J., and Trilling, L., Some problems of laminar boundary layer shock wave interaction, Heat Transf. and Fluid Mech. Inst., Calif. Inst. Tech., Pasadena, Calif., June 1957, 138–158.

2506. Gutkin, A. M., Equilibrium of a viscous plastic dispersion system on a rotating disk (in Russian), *Kolloidn. Zh.* **19,** 1, 31–34, 1957; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10886.

Turbulence

(See also Revs. 2452, 2481, 2601, 2602)

2507. Meecham, W. C., Relation between time symmetry and reflection symmetry of turbulent fluids, *Phys. Fluids* **1,** 5, 408–410, Sept.-Oct. 1958.

An assumption of statistical reflection symmetry is proposed for certain turbulent flows. On the basis of this assumption it is shown theoretically that some space-time velocity correlations characterizing the flow are even functions of the time delay between the correlation measurements. In particular the second- and

one of the fourth-order velocity correlations are symmetric in this relative time. R. C. Binder, USA

2508. Mills, R. R., Jr., Kistler, A. L., O'Brien, V., and Corrsin, S., Turbulence and temperature fluctuations behind a heated grid, *NACA TN* 4288, 27 pp. + 31 figs., Aug. 1958.

Temperature and velocity fluctuations were measured with hot-wire techniques behind a hot grid in a wind tunnel with a mean air velocity of 14 fps and temperature rise of 5C.

For isotropic turbulence double and triple correlation coefficient functions were considered and found to be of the same spatial extent for vector and scalar fields. Temperature fluctuations died out more slowly than turbulence.

Authors are uncertain of universality of results.

A. Sesonske, USA

2509. Kraichnan, R. H., Higher order interactions in homogeneous turbulence theory, *Phys. Fluids* **1**, 4, 358–359, July-Aug. 1958.

In *Phys. Rev.* **109**, p. 1407, 1958, author presented a theory of homogeneous turbulence based upon the weak-dependence and direct-interaction hypotheses. Present note states in physical terms reasons for the second hypothesis to be replaced by an approximation, since it has been found not to be exact. Details are to be published later. R. E. Street, USA

2510. Deissler, R. G., On the decay of homogeneous turbulence before the final period, *Phys. Fluids* **1**, 2, 111–121, Mar.-Apr. 1958.

On the basis of the publications by Taylor, Kármán, Howarth, Proudman, Reid and Tatsumi, author develops further the theory of homogeneous turbulence. The computation of the state of turbulence in the final period is reduced to the solution of equations which give for two or three points the correlation between velocity and pressure. These equations are derived in the usual way from the equations of momentum and continuity and subsequently transformed, using the three-dimensional Fourier transform. The energy transfer function describes the transfer of energy between the different eddies. The spectrum function is equivalent to the contributions of the various eddy sizes to the total energy.

The state of turbulence computed for $Re = 650$, 950 and 1360 agrees closely with the measurements by Batchelor and Townsend.

M. Strscheletsky, Germany

2511. Avetkiov, A. G., The length of an eddy in a unilateral plane expansion of a jet in a limited space (in Russian), *Izv. Vses. N.-i. In-ta Gidrotekh.* **54**, 27–37, 1955; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4280.

Examination of the case of unilateral spreading of a flow in a prismatic course of rectangular section. The section of the flow on the initial length is H_1, B_1; on the final one H_2, B_2. The expansion is effected in one stage, normal to the bank. The relationship B_2/B_1 lies within the limits of 1 and 4.5.

The discharge of the eddy zone is determined in rough approximation by two paths. The length of the eddy L is found from the calculations. The expression for L is used in the interpretation of the test data on expansion obtained by Soviet authors. From the tests, $L/(B_2 - B_1) = 3.7 \div 6.6$. A. S. Ofitserov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2512. Miln, V. B., and Ermilov, N. D., Influence of turbulence on the conductivity of air under the action of electrical fields (in Russian), *Uch. Zap. Kirovskii Ped. In-ta* **1**, 8, 21–28, 1954; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4454.

An exposition and analysis of the results of special tests on the artificial ionization of the atmosphere, whose objective was to study the influence of turbulent mixing on the electrical conductivity in a layer of air near the earth. The method of artificial ion generators is suitable for evaluation of the coefficient of turbulence in a layer of the atmosphere near the ground. In particular, the coefficient of turbulence is clearly connected (in the case of the given stratification of the layer near the earth) with the relationship of the values of conductivity at two levels at the same distance from the linear source of the ions. The corresponding tests which were made in 1954 showed that the value of the coefficient of turbulence determined from the data of the ion generators and from the gradient observations are close to one another and show a parallel development from test to test. There is a description of the apparatus used for the artificial ion generators and for measurement of the conductivity. Tests were also made with a plane (vertically disposed) source of ions.

L. S. Gandin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2513. Ryazanov, G. A., Application of eddying electric fields when modelling plane circulation flows by the EGDA method (in Russian), *Tr. Leningr. In-ta Inzh. Vod. Transp.* no. 23, 219–222, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10734.

Aerodynamics

(See also Revs. 2312, 2448, 2462, 2463, 2471, 2475, 2489, 2502, 2524, 2553, 2558, 2559, 2564, 2645, 2662, 2667, 2669, 2724)

2514. Rogers, M., Aerothermoelasticity, *Aero/Space Engng.* **17**, 10, 34–43, Oct. 1958.

2515. Fiecke, D., Aerodynamic problems in the development of subsonic and supersonic wings (in German), *ZVDI* **100**, 4, 133–146, Feb. 1958.

2516. Keulegan, G. H., and Carpenter, L. H., Forces on cylinders and plates in an oscillating fluid, *J. Res. Nat. Bur. Stands.* **60**, 5, 423–440, May 1958.

The inertia and drag coefficients of cylinders and plates in simple sinusoidal currents are investigated analytically and experimentally. The average values of the inertia and drag coefficients over a cycle are determined from measurements of the out-of-phase and in-phase components of the force history. It is shown that the variations correlate with a dimensionless period parameter $U_m T/D$. Here U_m is the maximum velocity in the cycle, T the period, and D the diameter of cylinder or width of plate. The experimental data had so little scatter that the variations of inertia and drag coefficients with the higher harmonics $T/3$ and $T/5$ were also obtained. These variations also correlated with $U_m T/D$ and were a maximum when this parameter was equal to 15. Visual studies employing dye indicate that this value is reached just prior to the formation of a steady Kármán street. The experimental equipment, techniques, and procedures are described in detail, and prior research in this field concisely reviewed. The meticulous attention to second-order detail in this investigation accounts for the high quality and usefulness of the experimental results. J. P. Craven, USA

2517. Reed, W. H., III, Effects of a time-varying test environment on the evaluation of dynamic stability with application to flutter testing, *J. Aero/Space Sci.* **25**, 7, 435–443, July 1958.

The influence is studied of unsteady testing conditions on the observed stability of a system. The effects of time-varying parameters on the apparent stability measured from the transient motion are analyzed for a single-degree-of-freedom system. The re-

sults are used to predict shifts in flutter boundaries and changes in modal damping due to unsteady testing conditions.

Various frequency sweep techniques are discussed. A few examples of analog computer flutter studies are given. It appears that acceleration measurements can be about three times as sensitive to the effects of time-varying conditions as displacement and velocity measurements. M. Botman, Canada

2518. Furlong, G. C., and McHugh, J. G., A summary and analysis of the low-speed longitudinal characteristics of swept wings at high Reynolds number, *NACA Rep.* 1339, 44 pp. + 48 tables, 1957.

Report presents the more significant wind-tunnel data, as of August 15, 1951, of swept, delta, and then unswept wings. Most of the data were obtained at a Reynolds number of 6 million. However, some results at Reynolds numbers as low as 4 million have been included.

Two different types of separation are possible; leading-edge and trailing-edge. The type of separation depends primarily on the radius and angle of sweep of the leading-edge, the Reynolds number, and the aspect ratio. Once the type of separation is identified, generalized trends in lift, drag, and pitching moment can be established. Either type, or a mixture, may occur on a swept wing.

Longitudinal stability characteristics can be misleading if the test Reynolds number is below the flight value. Satisfactory longitudinal stability for a wide range of sweep, aspect ratio, and taper ratio can be assured empirically whenever the wing area aft of the quarter-chord point of the mean aerodynamic chord exceeds 69% of the total wing area.

Effectiveness of various stall control devices appropriate to each type of flow separation is discussed, including fences, leading-edge flaps and slats, droop noses, chord-extensions, and boundary-layer control; also considered are nacelles, stores, contra flaps, camber and twist, and unusual planform shapes.

The vertical position of the horizontal tail has a prominent effect on the over-all stability due to the strong influence of the wing wake on downwash. Procedures for predicting tail effectiveness are given. Various methods and/or charts are compiled for the prediction of lift-curve slopes and maximum lift with and without high-lift and stall control devices. Experimental data on profile drag, Oswald's efficiency factor, and calculated induced drag are also given.

An extensive list of references (136) is included, and all test data are handily summarized in 48 tables which make up about two-thirds of the entire report.

Reviewer considers this a very useful summary compilation of aerodynamic data. With a 1957 re-publication date, however, one wonders if the title could not have been changed to indicate the vintage of the experimental data. H. P. Liepman, USA

2519. Tobak, M., and Allen, H. J., Dynamic stability of vehicles traversing ascending or descending paths through the atmosphere, *NACA TN* 4275, 28 pp. + 3 figs., July 1958.

Paper studies the motion of a nonpowered vehicle in a skip flight in a vertical plane. The special case studied in detail permits generalization of the oscillatory motion about any c.g. trajectory within practical restrictions on the latter. The following simplifying assumptions are made: Aerodynamic coefficients independent of M and R; constant L/D; a C_d independent of angle of attack and pitch velocity; a density altitude defined by $\ln \rho/\rho_0 = -\beta_0 y$, β_0 a constant; zero gravity force. The equations of motion are separated into two parts; one representing a mean c.g. motion presumably not effected by the second, an oscillatory motion about this c.g. The c.g. trajectory is found in terms of the flight path angle as a parameter. After empirical reduction of the nonlinear term of the equation for the oscillatory motion, the latter is solved in terms of the J_0, J_1, Y_0 and Y_1 Bessel functions. Several particularly simple examples are presented. It is shown that the oscillatory motion is independent of the c.g. trajectory whenever the direction of flight does not change rapidly with altitude. A particular case studied to examine the effect of the zero gravity simplifications disclosed that there can be a significant effect on the oscillation frequency and the need for correction of the penetration altitude. Interesting generalized information is found. M. G. Scherberg, USA

2520. Westbrook, C. B., and McRuer, D. T., Aircraft handling qualities and pilot response characteristics, *AGARD Rep.* 125, 11 pp. + 2 tables + 8 figs., May 1957.

2521. Maruhn, K., Aerodynamic research on fuselages with rectangular cross section, *NACA TM* 1414, 19 pp. + 29 figs., July 1958.

Vibration and Wave Motions in Fluids

(See also Rev. 2474)

2522. Hufft, J. C., Laboratory study of wind waves in shallow water, *Proc. Amer. Soc. Civ. Engrs.* **84,** WW 4 (*J. Waterways and Harbors Div.*), Pap. 1765, 20 pp., Sept. 1958.

Waves were generated in shallow water by forcing air through a wave channel. Data on wind velocity, fetch, and wave parameters fit wave-length curves that are the same as for deep-water generation. Effect of shallow bottom is to increase height more rapidly than in deep-water generation until partial breaking occurs.

R. S. Arthur, USA

2523. Hicks, B. L., and Huber, E. A., Growth of small water waves with wind speed and fetch, *Phys. Fluids* **1,** 5, 454–455 (Letters to the Editor), Sept.-Oct. 1958.

2524. Teipel, I., The influence of a local cross-section change on the two-dimensional wave by linearized theory, *J. Aero/Space Sci.* **25,** 8, 532–533 (Readers' Forum), Aug. 1958.

2525. Rudnick, I., On the attenuation of finite amplitude waves in a liquid, *J. Acoust. Soc. Amer.* **30,** 6, 564–567, June 1958.

An expression is obtained for the rate of attenuation of large amplitude waves of stable form propagated in a liquid whose attenuation varies as the square of the frequency. Calculations are presented for several liquids and comparison is made with recent published data. From author's summary

2526. Gouyon, R., On the plane steady movement of a homogeneous heavy liquid (in French), *C. R. Acad. Sci., Paris* **246,** 9, 1375–1378, Mar. 1958.

Steady motion equations are expressed in terms of a stream function $\sqrt{g}\psi$, where g is presumably acceleration of gravity, and vorticity $\sqrt{g}\, f(\psi)$. It is then shown that near free surface vorticity is a given analytic function of stream function. Barotropic motions are shown to lead to Gerstner waves.

Paper appears to be little more than an abstract.

J. M. Robertson, USA

2527. Bhattacharya, R. N., Generation of fluid motion by a source moving parallel to and slightly below the free surface of a fluid, *Intern. Shipbldg. Progr.* **5,** 43, 115–120, Mar. 1958.

A fluid source is considered to start from rest and move at constant velocity below and parallel to an initially plane fluid surface. Expressions for velocity potential and surface elevation are given in terms of steady-state values plus transient deviations. It is shown that a steady-state condition is quickly reached when a

frictional force, proportional to the velocity, is assumed but that neglect of the frictional force results in a somewhat longer transient state. The transient portion of the expression for fluid surface elevation is reduced very quickly with distance from the fluid source. This impulsive motion problem extends the previous work of Havelock, Lunde and Lamb and sheds further light on problems of wave resistance. R. B. Banks, USA

2528. Jolas, P., Approximate calculation of irrotational wave (in French), *C. R. Acad. Sci., Paris* **246**, 11, 1659–1661, Mar. 1958.

Stokes' formulas, used for the approximate calculation of the one-dimensional, oscillatory, irrotational, steady wave of finite amplitude, are expressed by a simple transformation with complex quantity. Characteristics of the wave previously found by Struik and some results of Peney and Price [see AMR **5** (1952), Rev. 2872] are obtained. G. Noseda, Italy

2529. Krylov, Yu. M., New foreign researches on wind-induced waves (in Russian), *Meteorol. i Gidrologiya* no. 9, 49–54, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6716.

A survey of American researches on wind-induced waves. Principal attention is paid to the work of Pearson and Neuman, who first extensively applied the technique of probability analysis to wind-induced waves. It is pointed out that by this means, compared with the Sverdrup-Munk theory, considerable progress has been attained in the kinematic description of the events. The fundamental defect of this new conception is, in the opinion of author, the absence of a clear dynamic picture and neglect of the mechanism of turbulence. N. N. Moiseev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2530. Sharova, I. F., Investigation of the particular solutions of the problem of waves on the surface of a viscous liquid (in Russian), *Trudi Mor. Gidrofiz. In-ta Akad. Nauk SSSR* **8**, 33–43, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5584.

The linear problem is investigated of waves on the surface of a heavy viscous liquid of infinite depth, when the surface is stress-free. It is assumed that the normal to the wave surface varies but little from the vertical straight and therefore is replaced by the vertical. Discarding the nonlinear members in the equations of Navier-Stokes and recording them and the equation of continuity in cylindrical coordinates, author looks for a particular solution in the form of

$$v_r = e^{-\alpha t+is\varphi}(A_1 e^{kz} + A_2 e^{mz})[J_{s-1}(\chi r) - J_{s+1}(\chi r)]$$

$$v_\varphi = e^{-\alpha t+is\varphi}(D_1 e^{kz} + D_2 e^{mz})\frac{s}{r} J_s(\chi r)$$

$$v_z = e^{-\alpha t+is\varphi}(B_1 e^{kz} + B_2 e^{mz}) J_s(\chi r)$$

$$p = e^{-\alpha t+is\varphi}(C_1 e^{kz} + C_2 e^{mz}) J_s(\chi r) - \rho g z$$

where s and χ are given values, while the remaining constants are determined from the equations and the boundary conditions; s is a whole number, k and $m > 0$. The conditions on the free surface are transferred, as is customary in the linear theory, onto the undisturbed level. After the determination of the constants the author sorts out the correlations between the length of the vertical wave and its frequency. The free surface is expressed by the equation

$$\eta = ae^{-\alpha t+imx}\cos ny$$

For the particular solutions examined the correlation between the length of the wave and the frequency in polar and Cartesian coordinates according to external form is the same as in the plane case of Cartesian coordinates. A. K. Nikitin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2531. Levitskii, B. F., The extinction of energy in the union of the "upper" and "under" waters, of the type of an unflooded surface jump (in Russian), *Dokladi L'vovsk. Politekhn. In-ta* **2**, 1, 73–76, 1955; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5552.

A short account is given of the results of experiments carried out to establish the effects of the extinction of energy during the union of the depths not flooded by a surface hydraulic jump. As an example of the basic character of the extinction of energy (or more accurately, the dissipation of energy) the case is taken of intensivity of the change of the quantity of motion along the current, determined on the basis of the analysis of the given measurements of the equally acting pressures in the different sections of the current. Author deduces that the unflooded surface jump acts in a lesser degree as the extinguisher of energy than the bottom hydraulic jump. It should be noted that the analogous deduction can be easily arrived at by comparison of the magnitude of energy losses determined with the aid of Bernoulli's equation for the surface and bottom hydraulic jumps. M. F. Skladnev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2532. Levitskii, B. F., Study of the distribution of pressure on a portion of the first half-wave of a surface jump (in Russian), *Dokladi L'vovsk. Politekhn. In-ta* **1**, 2, 48–50, 1055; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5551.

Results are given of experimental investigations on the distribution of pressures in a series of characteristic sections of a portion of the first half wave of a surface hydraulic jump. In particular, the author cites the following cases: (1) In the section of the crest of the first half wave, in the transit current or under the current, a vacuum is formed only in the case where the surface jump is close to flooding. (2) The distribution of pressure under the current in the bottom eddy is in accordance with the linear principle. A similar pressure distribution takes place also in the current and in the eddy in the plane of the shelf. Exceptions are the cases where the height of the shelves is small. (3) The principle of the distribution of pressure in the section of the largest twist of the current in the limits of the first half wave is very close to the hydrostatic principle. As in the other paper by the author [see preceding review], no material of any sort is put forward to give an idea of the experimental apparatus used and of the range of change of basic parameters employed, within whose limits the phenomenon of the surface jump was studied. M. F. Skladnev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2533. Arsenishvili, K. I., Criteria of wave formation in canals with large slopes (in Russian), *Gidrotekh. Stroit.* no. 3, 41–44, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10381.

Results are given of the experimental verification of the criteria of wave formation put forward by V. V. Vedernikov, G. Thomas, M. A. Mostkov and N. A. Kartvelishvili. The checks were carried out in natural conditions in actual installations and in laboratory conditions (in tanks) of rectangular, trapezoidal and triangular shape with angles of 90 and 150° at the apex and segmental section. The experiments showed that all the recalculated criteria basically do not reflect the character of the motion at maximum contents or discharges. In agreement with the criteria for these factors there should be wave motion present, but actually none was observed. In addition, the criteria of V. V. Vedernikov and N. A. Kartvelishvili do not take into account the influence of the form of the transverse section of the canal on the possible nature of motion of water in it, or do not take sufficient account of it. By taking into account the frictional forces on the wall and the influence of the form author obtains criteria which, in his view, better reflect the actual regime of the motion. K. Chadaeva

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2534. Reismann, H., Liquid propellant inertia and damping due to airframe roll, *Jet Propulsion* **28,** 11, 746–747 (Tech. Notes), Nov. 1958.

Theoretical study of response of a fluid in a smooth-walled cylindrical tank subjected to sinusoidal oscillations in roll. Solution of Navier-Stokes equation proceeds by means of Bessel functions to obtain effective moment of inertia of fluid and damping. Results are plotted as function of frequency.

W. C. Griffith, USA

2535. Edge, P. M., Jr., and Mason, Jean P., Hydrodynamic impact loads on 30° and 60° V-step plan-form models with and without dead rise, *NACA TN* 4401, 8 pp. + 1 table + 9 figs., Sept. 1958.

Tests were made at the Langley impact basin with models having round keels, straight intermediate sections, and chine flare. These tests were made in smooth water at fixed trims over a range of landing conditions at a beam-loading coefficient of 3.6. The data of the two models are compared to show effects of planform angle on impact loads, and the 30° V-step data are compared with data for the flat-bottom model [*NACA TN* 2932] to show dead-rise effects for the V-step configuration.

From authors' summary

2536. Miche, R., Laboratory wave damping results and their interpretation (in French), *Houille Blanche* **13,** 1, 40–74, Jan.-Feb. 1958.

2537. Dolgachev, F. M., Marchenko, A. S., and Smirnov, G. N., An appliance for measuring wave heights in laboratory conditions (in Russian), *Sb. Trudi Mosk. Inzh.-stroit. In-ta* no. 9, 62–64, 1955; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6722.

The receiver consists of two metal electrode rods closing an electrical circuit when in contact with water. Depending on the depth of immersion of these rods below the water surface, the current intensity in the circuit varies, the variations being recorded on the oscillograph screen.

P. A. Volkov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2538. Marchenko, A. S., and Smirnov, G. N., An instrument for measuring the height of advance of a wave up a slope (berm) (in Russian), *Sb. Trudi Mosk. Inzh.-stroit. In-ta* no. 9, 56–61, 1955; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6723.

The apparatus is based on the principle of fixing the height of advance of the wave by several pairs of insulated contact plates fitted on the slope at regular intervals in height. On making contact with the water flowing up the slope after breaking of the wave, each pair of plates closes an electrical circuit. This is recorded on corresponding electrical pulse counters connected in the circuit of each pair of plates. The indications of the counters show the number of waves running up the slope and the number of rolls on individual points of the slope.

P. A. Volkov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2539. Dmitriev, A. A., and Bonchkovskaya, T. V., Laboratory arrangement for investigation of the wave motion of a liquid (in Russian), *Trudi Mor. gidrofiz. in-ta Akad. Nauk SSSR* **7,** 67–71, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4319.

A description is given of a laboratory arrangement for studying motion in a wave by light polarisation methods. This was developed in the Maritime Hydrophysical Institute of the Akad. Nauk SSSR. The wave trough is made of plexiglass and has a length of 400 cm, a width of 13 cm, and a height of 35 cm. For wave damping, dampers of differing design are specified, dependent on the dimensions of the waves excited by a wave generator. Authors developed an oscillation excitor of a wave impeller which ensures the stability of the period of the waves produced in case of impairment of the stability of the voltage in the electric circuit.

A. A. Kostyukov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2540. Gourceaux, M., Forced vibration of a very diluted suspension having small elastic spheres; application of ultrasonics for different destructive purposes (in French), *C. R. Acad. Sci. Paris* **246,** 9, 1374–1375, Mar. 1958.

Fluid Machinery

(See also Revs. 2368, 2445, 2447, 2593, 2643, 2668, 2684)

2541. Fanti, R. A., Kemp, N. H., and Nilson, E. N., A theory of thin airfoils, isolated and in cascade, yielding finite pressures at smooth leading edges, *J. Aero/Space Sci.* **25,** 7, 409–424, July 1958.

First a staggered cascade of airfoils is mapped into a cascade of slits, which in turn are transformed into a circle. The complex velocity u-iv is expressed in the circle plane by the usual Poisson integrals involving either u or v. With u expressed in terms of an integral involving v, v is replaced by $u(dy/dx)$, and so a singular integral equation is established for u. This is solved by an iterative procedure.

The method avoids the usual leading edge singularity of thin airfoil theory without involving the extensive numerical work of Garrick's [*NACA TR* 788, 1944] exact method.

L. C. Woods, Australia

2542. Abe, S., Theoretical research on experimental devices for straight lattice of airfoils (in English), *Rep. Inst. High Speed Mech., Tohoku Univ. (B)* **9,** 81/90, 1–19, 1958.

Experimental arrangement to simulate an infinite cascade of airfoils consists of a set of blades in a free jet or between suitably shaped walls. Flow past these blades is calculated by means of successive approximations, using thin airfoil theory. Results are claimed to be useful for choosing wall shapes and for interpreting experimental results as compared with infinite cascade theory.

G. Moretti, USA

2543. Zhukovskii, M. I., Design of cascades of airfoils with prescribed velocity distribution in subsonic flow (in Russian), *Energomashinostroenie* no. 5, 14–18, May 1956.

Paper summarizes some known methods of solutions of the inverse airfoil problem for a cascade of airfoils in compressible, potential flow. Two practical methods, based on the tangent gas approximation (ratio of specific heats = −1) and illustrated by numerical examples, are presented. Closure of profiles is obtained by adjustment of the prescribed velocity distribution. No particular method of velocity adjustment is suggested.

C. P. Kentzer, USA

2544. Emin, O. N., Secondary flow and losses during the motion of liquids when turning (in Russian), *Tr. Mosk. Aviats. In-ta* no. 68, 82–104, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10358.

An investigation is made of a steady flow of an incompressible viscous liquid through a grid, as through a circular channel of rectangular section. A formula is proposed for the calculation of the coefficient of secondary losses, which corresponds satisfactorily with the known empirical formula of hydraulic losses in the bend of a tube [G. N. Abramovich, *Tr. Ts AGI*, no. 211, 1935] and is confirmed by the author's own measurements of flow in the turbine's controlling apparatus. The theoretical analysis of the question is based on a series of clumsy and unorthodox assumptions. The contemporary presentation and the various methods of

solution of the problem being investigated may be ascertained in, for instance, the works of Erich, Detr, Kaming, Major. According to the formula proposed by the author the coefficient of secondary losses is proportional to the thickness of the boundary layer at the inlet to the grid, which, in the case of a viscous liquid, is not correct. L. G. Naumoua and G. Yu. Stepanov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2545. Meyer, A. J., Jr., and Morgan, W. C., Structural design and preliminary evaluation of a lightweight, brazed, air-cooled turbine rotor assembly, *NASA Memo* 10-5-58E, 11 pp. + 13 figs., Dec. 1958.

A light-weight air-cooled turbine rotor assembly intended for short-life expendable missile application and which results in a 50% weight reduction over a conventional turbine was devised and stress analyzed. Two rotor blade configurations with simulated full-wheel attachment were tested in a full-scale engine. The better blade configuration endured 8½ hours at rated speed before a vibration failure occurred. Several means for overcoming the vibration problem are suggested in order to increase the blade life appreciably or to allow further weight reductions.

From authors' summary

2546. Stewart, W. L., Torque-speed characteristics for high-specific-work turbines, *NACA TN* 4379, 12 pp. + 9 figs., Sept. 1958.

Report presents an investigation of turbine torque-speed characteristics in a general form using the ideal specific work output corresponding to turbine static-to total-pressure ratio as normalizing parameter. These characteristics are first obtained using reference single-, two-, and three-stage analytical efficiency curves in the high-specific-work turbine operating range. Comparison of the results with available experimental data is then made to verify the trends of curves presented.

These analytical curves are used to provide a basis for estimating starting torque margin as a function of design-point requirements. An example turbodrive application is also described to illustrate how torque-speed curves can be used to establish staging effects on these characteristics. Adding stages and reducing criticalness of design with respect to relation of specific work output to blade speed result in improved starting torque margin.

From author's summary by P. G. Schwaar, France

Flow and Flight Test Techniques and Measurements

(See also Revs. 2467, 2596, 2609, 2626, 2673, 2674)

2547. Dimeff, J., A survey of new developments in pressure measuring techniques in the N. A. C. A., *AGARD Rep* 166, 11 pp. + 23 figs., Mar. 1958.

Several transducers designed to meet the particular needs of research within the N.A.C.A. are described: an inexpensive strain gage transducer with an accuracy of 0.05% of its full differential range; a deflecting diaphragm capacitance-type transducer for the range below several millimeters of mercury; a transducer 1/8 in. in diameter and an experimental transducer in which the deforming member is a thin layer of dielectric compressed under the action of the unknown pressure. From author's summary

2548. Davis, W. T., Lag in pressure systems at extremely low pressures, *NACA TN* 4334, 8 pp. + 8 figs., Sept. 1958.

Measurements of the time lag in pressure-measuring systems (as for instance used in aircrafts and wind tunnels) are reported and compared with theoretical formulas. These had been given earlier by W. J. Chamley [*ARC Rep. Mem.* 2352, 1950] and W. A. Wildhack [*NACA TN* 593, 1937] for pressures in the continuum-flow region. Starting from a general formula by Gordon P. Brown and others [*J. Appl. Phys.* **17**, 10, 802-813, Oct. 1946] for gas flow rates at all pressures, authors derive an expression for the time lag in pressure-measuring systems covering both continuum and slip flow regions. Experimental data verify theory within an error of 10% for mean pressures as low as 0.2 mm mercury.

H. Schuh, Sweden

2549. Cowdrey, C. F., Temperature and pressure corrections to be applied to the shielded hot wire anemometer at speeds for which natural convective cooling is negligible, *Brit. J. Appl. Phys.* **9**, 3, 112-115, Mar. 1958.

The shielded hot-wire anemometer consists of a heated wire and a thermocouple mounted in a length of twin-bore silica tubing. It's advantage is constancy of calibration, the result of protection from fouling by dust particles in free airstream. Paper is a short discussion of properties of anemometer in measurement of mean velocity and application of Hilpert's law of cooling to calibration curve. Effects of air pressure and temperature are considered in particular. Two series of experiments were designed to assess variations of these quantities. Results verify the analysis.

Reviewer believes paper is of interest to anyone engaged in measurement of relatively low air velocities. Using author's methods it should be easy to maintain an accuracy of less than 1%. W. D. Baines, Canada

2550. Davies, P. O. A. L., The behaviour of a pitot tube in transverse shear, *J. Fluid Mech.* **3**, 5, 441-456, Feb. 1958.

Paper describes low-speed experiments with flat-ended cylindrical pitot tubes in wakes and in a turbulent boundary layer. In the wakes the displacement correction was found to obey a relationship of the form derived by Hall [AMR **10** (1957), Rev. 4071] and by Lighthill [*J. Fluid Mech.* **2**, p. 493, 1957]. In the wake close behind the trailing edge an additional velocity-head error, ascribed to the effect of yaw, was found to exist. This error depends not only on velocity gradient and pitot-tube geometry but also on the dynamic characteristics of the flow. For a conventional pitot tube no corrections were observed in a turbulent boundary layer. N. H. Johannesen, England

2551. Bryer, D. W., Walshe, D. E., and Garner, H. C., Pressure probes selected for three-dimensional flow measurement, *Aero. Res. Counc. Lond. Rep. Mem.* 3037, 11 pp. + 4 tables + 14 figs., 1958.

Seven pressure probes have been tested in a uniform stream in order to ascertain the best types for measuring velocity and flow direction. Methods of calibration are discussed together with the effects of wind speed, flow direction and turbulence on the calibration factors.

The performance of three of the probes in the turbulent boundary layer of a flat plate is analyzed and their accuracies compared when they are used to estimate displacement and momentum thickness.

The Conrad probe is proved superior to other types for boundary-layer measurements. Further research on the lines indicated in section 7 is necessary before the best type of probe for use in regions of separated flow can be ascertained. The main features of the velocity-measuring probes are listed in Table 4.

For measuring static pressure in three-dimensional flow, a disk type of probe is described and shown to be insensitive to flow direction and scale effect. From authors' summary

2552. Heyser, A., Development of pressure measuring devices for a blow-down wind tunnel at the D. V. L., *AGARD Rep.* 165, 9 pp. + 17 figs., Mar. 1958.

The development of pressure-measuring devices for a blow-down wind tunnel at the Deutschen Versuchsanstalt für Luftfahrt (D.V.L.) at Aachen, Germany. The economic utilization of an intermittent wind tunnel is considered and it is shown that measuring devices with rapid response times are necessary for use in such a tunnel. Measuring devices discussed include electronic multimanometers and a miniature differential pressure transducer, as well as instrumentation for the measurement of stagnation pressure. Consideration is also given to the question of what response times can be realized under normal conditions of operation.

From author's summary

2553. Emerson, H. F., and Robinson, R. C., Experimental wind-tunnel investigation of the transonic damping-in-pitch characteristics of two wing-body combinations, *NASA Memo* 11-30-58A, 11 pp. + 11 figs., Dec. 1958.

The results of an experimental wind-tunnel investigation of the damping-in-pitch of two wing-body combinations are presented through the transonic Mach number range. One model had a straight, tapered wing of aspect ratio 3 and the second model had a triangular wing of aspect ratio 2. The Mach number range was from 0.60 to 1.18 and the Reynolds number varied from 2.3 million to 5.5 million. The results were obtained by a forced-oscillation technique in which an electrohydraulic servo valve was used to power the drive system. From authors' summary

2554. Covert, E. E., A summary of experiments with slotted transonic inserts in the Naval Supersonic Laboratory Wind Tunnel, Mass. Inst. Technol. Naval Supersonic Lab. TR 207, 29 pp. + 39 figs., Apr. 1958.

The calibration of the transonic nozzle blocks for the Naval Supersonic Laboratory Wind Tunnel indicates that the useful Mach number range is between 0.5 and 1.30 and that the distribution is relatively uniform. These results were obtained with a calibration pole and are expected to hold for all bodies of revolution of length twelve inches or less and winged bodies whose span is eight inches or less.

The measurements indicate that, for bodies with a blocking area up to one and one half percent of the tunnel area, the slots deblock as expected by the theory. Further, models with a length of two-thirds of the tunnel height or less, and whose span is forty-five percent of the tunnel height or less, may be tested on a development basis, provided a suitable correction is made for a flow inclination.

Some auxiliary results are given which help explain the phenomena encountered in slotted tunnels.

From author's summary

2555. Salmi, R. J., A three-dimensional flow expander as a device to increase the Mach number in a supersonic wind tunnel, *NASA Memo* 10-6-58E, 3 pp. + 3 figs., Dec. 1958.

The operating characteristics of a 5° conical-flow expander were investigated in the Lewis 2- by 2-foot Mach 3.88 wind tunnel to determine the feasibility of using this type of device to increase the Mach numbers in conventional supersonic wind tunnels. The results indicated that this method should be practical.

From author's summary

2556. Squire, L. C., and Stanbrook, A., The influence of a model on plenum chamber indication of Mach number in a slotted wall wind tunnel, *Aero. Res. Counc. Lond. Curr. Pap.* 395, 6 pp., 1958.

In many transonic tunnels the Mach number in the working section is determined from a pressure measured in the plenum chamber, on the assumption that this pressure is uniquely related to the free-stream static pressure. The effect of a number of different sting-mounted models of solid blockage up to about ½% on this relationship has been investigated in the 3-ft tunnel at RAE Bedford. The results show that the Mach number determined from the pressure in the plenum chamber is not affected by the presence of any of the models in the working section, provided that the pressure is not measured near the downstream end of the plenum chamber. From authors' summary

2557. Griffin, R. N., Jr., Holzhauser, C. A., and Weiberg, J. A., Large-scale wind-tunnel tests of an airplane model with an unswept, aspect-ratio-10 wing, two propellers, and blowing flaps, *NASA Memo* 12-3-58A, 10 pp. + 1 table + 18 figs., Dec. 1958.

An investigation was made to determine the lifting effectiveness and flow requirements of blowing boundary-layer control applied to a propeller-driven airplane. The blowing prevented flow separation on the flaps and increased the flap lift increment for flap deflections up to the maximum tested of 80°. The effect of the propeller slipstream was to increase the lift increment due to flap deflection. The blowing jet momentum coefficient required for attached flow on the flaps was unaffected by the propeller slipstream.

From authors' summary

2558. Rose, R., Wing flow measurements of the damping in pitch derivative of a 45° delta wing-body combination and with a tailplane in two positions, *Aero. Res. Counc. Lond. Curr. Pap.* 402, 6 pp. + 1 table + 6 figs., 1958.

Measurements of the damping in pitch derivative of a 45° delta wing-body combination and with a tailplane in two positions were made at transonic speeds using the wing flow technique. In the tailless configuration, the typical fall of $-(m_q + m_{\dot{w}})$ occurs at approximately $M = 0.92$ and agrees well with the available flight and tunnel tests. In the tests with the tail on, the damping contribution of the tailplane has been found and compared with theoretical estimates based on exposed tail area. The agreement is reasonable at supersonic speeds but poor at subsonic and sonic speeds.

From author's summary

2559. Gould, R. W. F., and Cowdrey, C. F., High Reynolds number tests on a 70° leading edge sweepback delta wing and body (H.P. 100) in the compressed air tunnel, *Aero. Res. Counc. Lond. Curr. Pap.* 387, 6 pp. + 1 table + 9 figs. + 7 plates, 1958.

Values of lift, drag and pitching moment coefficients are given for a model of the H.P. 100 delta wing with sharp leading edges and with a body attached, over a range of Reynolds numbers from 1×10^6 to 12×10^6 and at incidences up to 42°. Photographs of the traces of an oil/titanium oxide mixture, on the surface, indicating flow directions, are included. The results show no appreciable scale effect. From authors' summary

2560. Bogdonoff, S. M., Exploratory studies of hypersonic fluid mechanics, *AGARD Rep.* 142, 13 pp. + 16 figs., July 1957.

Using a helium hypersonic wind tunnel, exploratory studies have been made of the flow over simple two- and three-dimensional bodies at Mach numbers from 11 to 19. Detailed studies of the flow over a flat plate are reviewed and preliminary results are presented for other configurations, including flat plates with flaps, delta wings, base pressure models, blunt models (with and without spikes) and slim cones. Some preliminary results of boundary-layer studies and dissolving models are also discussed.

In the particular area of hypersonic fluid mechanics, the helium tunnel has proved to be an extremely valuable tool. Its simplicity and ease of operation have permitted a very wide range of studies to be carried out with relatively small effort. It has provided information on flow phenomena in a Mach number range not heretofore subject to detailed investigation. From author's summary

2561. Russo, A. L., and Hertzberg, A., Modifications of the basic shock tube to improve its performance, AFOSR TN 58-716 (Cornell Aero. Lab. Rep. AD-1052-A-7; ASTIA AD 162 251), 22 pp. + 18 figs., Aug. 1958.

Basic modifications are considered which would improve the performance of shock tubes in producing higher shock strengths and extend the use of hydrogen in generating strong shock waves in air. These modifications are the double-diaphragm driver with monatomic buffer gases and an area contraction at the diaphragm station. The results of this investigation indicate that the use of a shock tube with an area contraction and the proper monatomic buffer gas will permit the generation of strong shock waves, using cold hydrogen as a driver gas, with over-all pressure ratios comparable to those required for combustion drivers. It is also shown that, by using a buffer gas with the proper atomic weight, the downstream diaphragm pressure ratio may be controlled to minimize the mass of the downstream diaphragm.

From authors' summary

2562. Alpher, R. A., and White, D. R., Flow in shock tubes with area change at the diaphragm section, *J. Fluid Mech.* **3,** 5, 457-470, Feb. 1958.

Equations are derived for the calculation of properties of shock waves produced in a shock tube where the driver gas reservoir has a larger cross section than the shock tube. Real gas effects can be taken into account at the shock front, but isentropic, ideal gas flow is assumed for the flow from the reservoir into the shock tube The larger the reservoir cross section, the stronger the shock produced, all other conditions being equal. Experimental data are presented for ratios of reservoir to shock-tube cross section equal to 1.00 and 1.51. These are in good agreement with the calculations.

C. F. Hansen, USA

2563. Stollery, J. L., Real gas effects on shock-tube performance at high shock strengths, *Aero. Res. Counc. Lond. Curr. Pap.* 403, 12 pp. + 12 figs., 1958.

Calculations have been made to find the flow conditions behind shock waves in argon-free air of strengths $M_s = U/a_1$ up to about 35. The tables used are based on the currently accepted value for the dissociation energy of nitrogen of 9.758 e.v. per molecule, and are for equilibrium conditions.

Two cases only have been considered, namely

$$P_1 = \frac{1}{10}\text{ atm}, \qquad T_1 = 290\text{ K} \qquad [1]$$

$$P_1 = \frac{1}{100}\text{ atm}, \qquad T_1 = 290\text{ K} \qquad [2]$$

The driving conditions needed to produce such strong shocks have been calculated, assuming "ideal" hydrogen ($\gamma = 1.41$) to be the driving gas.

In conclusion, the test conditions available through expanding the flow behind the shock are presented for an expansion ratio of 225 and the question of flight simulation is discussed.

From author's summary

2564. Coleman, W. J., and DeSanto, D. F., Measuring in-flight thrust of a turbojet-powered aircraft, *AGARD Rep.* 197, 32 pp. + 11 figs., Apr. 1958.

Paper describes the theoretical formulation of a practical method for satisfactorily measuring the in-flight net thrust of a turbojet-powered aircraft. Authors discuss basic principles of thrust determination, current definitions and instrumentation techniques, including details of a traversing tailpipe rake.

From authors' summary

2565. Kaisner, R. W., Propulsion wind tunnel digital pressure system, *AGARD Rep.* 168, 9 pp. + 17 figs., Mar. 1958.

Report describes the digital pressure system of the Propulsion Wind Tunnel at the Arnold Engineering Development Center, Air Research and Development Command, U.S.A.F. This system is capable of measuring 4 reference pressures and 250 model pressures at a rate of 20 per second. Operating modes and reliability of the system are discussed.

From author's summary

2566. Brotherhood, P., Development and flight tests of an instrument flight director for helicopters, *Aero. Res. Counc. Lond. Curr. Pap.* 390, 14 pp. + 8 figs., 1958.

This note describes the development and flight testing of an instrument system which enables the pilot to fly a helicopter in instrument flight conditions with considerably less concentration or fatigue compared with that required using previous instruments. This instrument, which is intended to replace the present inadequate artificial horizon, gives longitudinal and lateral indications derived from the appropriate mixing of signals from angular displacement of the helicopter, rate of change of angular displacement and control position. The presentation is in the form of a zero-reader. No interpretation by the pilot of the helicopter's behavior is necessary, his only actions being to keep the instrument indications zero.

From author's summary

Thermodynamics

(See also Revs. 2470, 2485, 2563, 2591, 2598, 2627, 2632, 2639, 2640, 2642, 2644, 2651)

2567. Buchdahl, H. A., A formal treatment of the consequences of the second law of thermodynamics in Carathеodory's formulation, *Z. Phys.* **152,** 4, 425-439, 1958.

This presentation of Carathеodory's treatment of the Second Law makes use of a formal, rather than a mathematical or geometrical, development of Carathеodory's principle by considering the full content of the latter; that is, the accessibility of some neighboring states through irreversible processes. The treatment assumes the validity of the Zeroth Law and the existence of empirical temperature. Empirical entropy is shown to be an immediate consequence of Carathеodory's principle provided one assumes the impossibility of the mutual inaccessibility of neighboring states. The principle of increase of entropy is seen to follow when a necessary connection is made between positive temperature and positive entropy. A concluding development of the absolute temperature and entropy functions is given in a particularly simple form.

Reviewer believes the formal treatment is clearer than the original treatment of Carathеodory. Since it requires the use of the Zeroth Law and the postulate of the impossibility of mutual inaccessibility, it is less rigorous. The author makes clear, however, that the Clausius inequality is not contained within the Carathеodory hypothesis.

J. A. Fay, USA

2568. Lighthill, M. J., Dynamics of a dissociating gas. Part I. Equilibrium flow, *J. Fluid Mech.* **2,** 1, 1-32, Jan. 1957.

Several simplifying assumptions which are quite well justified are introduced in the calculations. These lead, for example, to a simple representation of the enthalpy of a dissociating gas when compared to the more exact form, without appreciable loss in accuracy. On these bases the author derives the inviscid flow equations and calculates the equilibrium flow about several bluff bodies.

In the opinion of the reviewer this is a typical Lighthill contribution which will serve as the foundation of much future work. The sections on flow past bluff bodies are of interest and importance in their own right, as well as illustrating the effects of equilibrium dissociating flow.

E. E. Covert, USA

2569. Schamp, H. W., Jr., Mason, E. A., Richardson, A. C. B., and Altman, A., Compressibility and intermolecular forces in gases: methane, *Phys. Fluids* **1,** 4, 329-337, July-Aug. 1958.

The compressibility of a sample of very pure methane has been measured with high precision from 0°C to 150°C and over a pressure range of about 20 to 230 atm. The precision attained is of the order of 1 part in 10^4. Small but consistent discrepancies exist between the present results and earlier measurements, and it is believed these discrepancies are the result of a small impurity of ethane in the methane used earlier. The virial coefficients of methane are redetermined from the present measurements, and the intermolecular forces of methane are calculated from the second virial coefficient for several forms of force laws. These force laws are then used to calculate the third virial coefficient, the crystal properties at 0°K, and the viscosity, for comparison with experiment. All the force laws fit the second virial coefficient very well, but some can be eliminated on the basis of the other properties. L. M. Grossman, USA

2570. Francis, W. E., Viscosity equations for gas mixtures, *Trans. Faraday Soc.* **54,** 10, 1492–1497, Oct. 1958.

A simplified relation between the viscosity of a gas mixture and the viscosities of the individual components is derived from the rigorous kinetic theory equations. The new relation appears to fit the known experimental data with an accuracy of about ± 2%, and can be applied to mixtures containing a polar component. The equation has been tested on a large number of mixtures of gases of widely differing molecular weights and viscosities, involving considerable departures from the simple mixing rules. The limitations of various equations which have been proposed in the past are discussed, and it is shown that the new equation probably represents the best approximation possible with one of the Sutherland-Thiesen type. From author's summary

2571. Boekemeier, D. W., Polynomial expressions for the specific heat and Prandtl number of air, *J. Aero/Space Sci.* **25,** 10, 658–659 (Reader's Forum), Oct. 1958.

Purpose of this note is to present polynomial expressions and their associated coefficients for the specific heat and the third root of the Prandtl number of air as functions of temperature. From author's summary

2572. Mason, E. A., and Saxena, S. C., Approximate formula for the thermal conductivity of gas mixtures, *Phys. Fluids* **1,** 5, 361–369, Sept.-Oct. 1958.

Starting from the Curtiss-Hirschfelder equations for the thermal conductivity of monatomic and polyatomic gas mixtures, authors derive simplified relations more suited to numerical calculation by making certain approximations based on physical arguments and experimental results. The polyatomic-gas-mixture relation is similar to the Lindsay-Bromley equation, the form of which is herein justified by well-defined approximations. The formulas proposed are tested by comparison with experimental results, agreement being nearly as good as obtained with the full-rigorous theory. L. M. Grossman, USA

2573. Hansen, C. F., Approximations for the thermodynamic and transport properties of high-temperature air, *NACA TN* 4150, 43 pp. + 8 tables + 11 figs., Mar. 1958.

Author computes thermodynamic properties of air for a range of temperatures from 500 K to 15,000 K and of pressures from 10^{-4} to 10^2 atmospheres, employing approximate partition functions for the major components of air. Other assumptions are made regarding the major constituents of air as a function of temperature. Calculations agree to within 5% with more exact calculations.

High-temperature transport properties of air are also calculated. To do this various approximations are used to estimate effective collision cross sections. Based on the work of Hammerling, Shine, and Kivel [*J. Appl. Phys.* **28,** 760–764, 1957] it would appear to this reviewer that the electron-atom cross section has been incorrectly estimated because author has not included Hartree (electrostatic) field plus polarization and exchange corrections. Result is to seriously underestimate the Prandtl number for fully ionized air, and to conclude boundary layers would be very transparent to heat flux. Actually, Prandtl number for fully ionized air is probably closer to 1/2 rather than the paper's value of 1/100. Reviewer also does not agree that heat-transfer experiments in dissociated air can serve to justify or invalidate the paper's computed values of transport properties. R. F. Probstein, USA

2574. Tsederberg, N. V., Thermal conductivity of compressed gases (in Russian), *Teploenergetika* **4,** 1, 45–48, Jan. 1957.

2575. Scheffe, H., Experiments with mixtures, *J. Roy. Stat. Soc.* (*B*) **20,** 2, 344–360, 1958.

2576. Gross, E. P., and Jackson, E. A., Kinetic theory of the impulsive motion of an infinite plane, *Phys. Fluids* **1,** 4, 318–328, July-Aug. 1958.

Half-range distribution functions are introduced in Boltzmann's equation and determined with the use of Laplace transforms. In contrast to the Navier-Stokes and Grad theories the method gives the exact initial stress and flow velocity of free molecular flow, and a boundary layer effect. P. E. Kriezis, Greece

2577. Johnson, D. E., and Ikenberry, E., Developments toward a series solution of the Maxwell-Boltzmann equation (in English), *Arch. Rational Mech. Analysis* **2,** 1, 41–65, Sept. 1958.

In this mathematical paper, the standard form of the linearized Maxwell-Boltzmann (M-B) integrodifferential equation of the kinetic theory of gases given by Chapman and Enskog is first rederived. The linearization is about the familiar Maxwell equilibrium distribution function F for molecular velocities: $F_0 = Ae^{-bc^2}$. It is then shown that the eigenfunctions (consisting of solid spherical harmonics and sonine polynomials) of the linearized collision operator are of the form obtained by Wang Chang and Uhlenbeck. Authors' proof avoids infinite series expansions. These eigenfunctions are valid for Maxwellian molecules, i.e. a molecular model with an inverse fifth power repulsive force, leading to significant simplications in the M-B integral. Authors then construct an exact and general theory for the linearized M-B equation, based on an expansion of F in terms of the complete set of the above eigenfunctions, describing azimuthal as well as radial and latitudinal variations in the velocity distribution. A physical interpretation of some of the coefficients in the expansion is given and it is noted that the equations of continuity, momentum, and thermal energy, which are also consequences of the exact M-B equation, can be obtained therefrom. Partial differential equations for the expansion coefficients are established. The external molecular forces considered are those due to an electromagnetic field, and it is mentioned that this may be of interest, for example, in connection with "magnetic bottles," hydromagnetic waves, cyclotron resonance, and theory of an ionized gas subject to a magnetic field. M. Morduchow, USA

2578. Filippov, L. P., Application of the theory of similarity to describing the properties of liquids. I: *P-V-T* correlations (in Russian), *Vestn. Mosk. In-ta* no. 1, 111–126, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 9857.

2579. Prigogine, I., and Philippot, J., On irreversible processes in nonuniform systems, *Physica* **23,** 6, 569–584, June 1957.

The present paper by Prigogine and Philippot is the eighth of a series of paper published in *Physica.* [See AMR **11** (1958), Rev. 4239; AMR **11** (1958), Rev. 4237; AMR **11** (1958), Rev. 4238; AMR **7** (1954), Rev. 3334; AMR **6** (1953), Rev. 3209; see also Peierls, R., "The Quantum theory of solids," Oxford Clarendon Press, 1955; Born, M., and Green, H., *Proc. Roy. Soc. Lond.* (*A*) **188,** p. 10, 1946; Ming Chen Wang and Uhlenbeck, G. E., *Rev. Mod.*

Phys. **17,** p. 323, 1945.] The objective of these papers is to establish a rigorous development of statistical mechanics for systems outside equilibrium, as Gibbs did for systems in equilibrium.

In this exposition, Boltzmann's equation, being a superposition of flow and collision terms, is considered as an intuitive result, valid only under certain conditions for which terms neglected by the Boltzmann equation are really negligible, as in the case of small macroscopic gradients.

The starting point of all efforts for a rigorous development of statistical mechanics outside equilibrium is the Liouville equation which was also the basis of Gibbs work for systems in equilibrium. The Liouville operator corresponding to the Hamiltonian of non-interacting microscopic systems is perturbed by a term which takes into account the existing coupling. Then an iteration method is used to obtain the equations for the Fourier coefficients of the spectrally decomposed distribution function. From these equations the evolution of the distribution function in phase space is obtained.

In the first papers of the series, the superposition principle used by Born and Green was criticized and the approach to equilibrium of a system of weakly coupled harmonic oscillators, homogeneous in space, was considered. In the present paper, macroscopic gradients are taken into account and the equations giving the evolution of the distribution function in the complete phase space (action and angle variables) are derived for the special case of weakly coupled harmonic oscillators. The coupling potential for the harmonic oscillators due to anharmonic forces is taken to be of a form given by Peierls which is used in the theory of solids. It is then found that the Fourier coefficients $\rho_{\{n\}}$ of the distribution function for this multiperiodic system satisfy equations of the form

$$\frac{\partial \rho_{\{n\}}}{\partial t} = \lambda^2 \Omega \rho_{\{n\}} - \lambda^2 M^2_{\{n\}} \rho_{\{n\}}$$

where Ω and M are given operators, the first of which is independent of $\{n\}$. Here $\{n\}$ is a set of N integrals, N being the number of oscillators. From these equations a generalized H theorem is obtained for the $\rho_{\{n\}}$'s, and under certain approximations an exponential decay of the correlations $\rho_{\{n\}}$ is shown to be valid.

In what follows, the above approach is applied to the Brownian motion of a system of harmonic oscillators and it is found that, in the case of spacially inhomogeneous systems, additional terms must be added to the Boltzmann' equation, namely, interference terms between decay and flow. These terms give a symmetric form to the above equation so that both the flow and the collision terms lead to irreversible behavior. It is also shown, for the Brownian motion, that a diffusion-type equation governs the evolution in coordinate space which is well known to be the case for action space. Finally, the propagation of mechanical perturbations in a linear lattice, treated in a previous paper for homogeneous systems only, is now extended to inhomogeneous systems also.

The originality of the paper is mainly the application of Liouville's equation in an inhomogeneous system of weakly coupled harmonic oscillators, and the modification of Boltzmann's equation into a more symmetric form for the case of the Brownian motion of coupled harmonic oscillators. This was done by including terms describing the interference between flow and collisions. It must be pointed out that this is not an independent paper, but rather a continuation of the previous contributions that have been published in *Physica.* E. N. Carabateas, USA

2580. Benedict, R. P., The calibration of thermocouples by freezing-point baths and empirical equations, ASME Ann. Meet., New York, N. Y., Nov.-Dec. 1958. Pap. 58-A-175, 12 pp.

A calibration system is described which is based on the use of a few precisely determined experimental values obtained from freezing-point baths. Characteristics of the individual thermocouples at intermediate points are obtained by passing empirical equations of prescribed form through the test values. A program is reviewed by which a high-speed digital computer accomplishes the necessary conversions, curve fittings, comparisons of individual characteristics with arbitrary reference tables, and the printing out of a table of differences. Test results for a series of iron-constantan thermocouples, over the temperature range 32–1225 F, are presented to illustrate the use of the system and the uncertainties involved. Comparisons are drawn between these results and those obtained by other methods.

From author's summary

2581. Krause, L. N., Johnson, R. C., and Glawe, G. E., A cooled-gas pyrometer for use in high-temperature gas streams, *NACA TN* 4383, 22 pp. + 8 figs., Sept. 1958.

Paper describes equipment used to measure gas temperatures to 4000 R. The gas is drawn through a cooled tube and its temperature determined at the exit. From a knowledge of transport properties of the gas and conditions of flow within the tube the change in temperature of the gas during passage through the tube is predicted. A knowledge of the exit temperature of the gas as well as the temperature change during passage through the cooling tube permits the original temperature to be determined. The theory is discussed and experimental data presented at gas temperatures from 2000 to 4000 R, and at total pressures from 0.8 to 1.5 atmospheres. The probable error reported for a single observation was ± 1%. Reviewer believes probable limitation lies in the need for accurate information concerning transport properties of gases at elevated temperatures, which is not available in many situations.

B. H. Sage, USA

2582. Blake, C., Chase, C. E., and Maxwell, E., Resistance thermometer bridge for measurement of temperatures in the liquid helium range, *Rev. Sci. Instrum.* **29,** 8, 715–716, Aug. 1958.

A 33-cps resistance thermometer bridge, suitable for precise temperature measurements in the liquid helium range, has been designed as a completely self-contained unit. The amplifier has a gain of 120 db, band width of 0.3 cps, and input impedance of 10 kohms. With a power dissipation of 2×10^{-8} watts in the thermometer, resistance changes of 0.1 ohm can be detected. For a typical resistance thermometer this corresponds to a temperature change of 4×10^{-6} K. Other features include high rejection of line-frequency pickup, short recovery time after saturation, and a combination gain band-width control which shortens the response time during preliminary balancing operations.

From authors' summary

2583. Deichman, B. S., Temperature measurements in a flow of gas at high velocities (in Russian), *Tr. Ufimsk. Aviats. In-ta* no. 2, 23–32, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10481.

An investigation is carried out on the influence of the M number on the coefficient of re-establishment of (stagnation) temperature r when $M \leq 2.0$ in the case of a transverse flow around a cylindrical thermocouple. The thermocouple used in the investigation consisted of copper and constantan wires 0.2 mm in diameter, soldered with silver solder without a bead. The experiments showed that (1) the coefficient of re-establishment of temperature in the region of Mach numbers < 1 alters very little with alteration of the M number and can be calculated by the formula $r = 0.7 + 0.11 (M - 0.35)$ [1]; (2) the coefficient of re-establishment of temperature in the range of Mach numbers > 1 increases with the growth of the M number and strives to attain a value of 0.9 when $M = 2.0$. The experimental points fit in well in the curve described by the equation

$$r = 0.9 - 0.14e^{-3.7(M-1)} \qquad [2]$$

The difference in conformity to rule $r = f(M)$ in the transonic and supersonic ranges is explained by the changes in the physical pic-

ture of the interaction of the thermocouple with the gas flow in transition through M = 1. L. N. Tryakova

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2584. Hall, J. G., and Hertzberg, A., Recent advances in transient surface temperature thermometry (Survey article), *Jet Propulsion* **28,** 11, 719–722, Nov. 1958.

Heat and Mass Transfer

(See also Revs. 2199, 2252, 2253, 2254, 2255, 2256, 2257, 2433 2449, 2456, 2465, 2496, 2508, 2571, 2572, 2573, 2574, 2577, 2580, 2581, 2582, 2583, 2584, 2725, 2726, 2727, 2728, 2729, 2730, 2732)

2585. Reismann, H., Two-dimensional periodic flow of heat in polar coordinates, *J. Franklin Inst.* **266,** 4, 293–300, Oct. 1958.

Author solves two-dimensional heat-conduction problem (with constant diffusivity) in polar coordinates r, θ if boundary temperature varies periodically with time (application in design and analysis of several equipments with circular boundaries and periodically alternating surface temperatures). He presumes the solution in the form

$$T(r, \theta, t) = F(r, \theta) \cos \omega t + G(r, \theta) \sin \omega t$$

(T temperature, t time, ω frequency).

Letting $\overline{W} = F + iG$, author obtains a differential equation for $\overline{W}$ which he solves in a series form, using Bessel functions of first and second kind. For unknown functions F and G he obtains series containing the well-known (and tabulated) functions ber, bei, ker, kei. Unknown coefficients of these series are determined by representing boundary conditions (in θ) on the circular boundary (or boundaries) by Fourier series and comparing coefficients.

The question of maximum and of temperature T at fixed time t_1 is solved.

Author presents as example a two-dimensional heat-conduction problem in an infinite region exterior to a circular boundary, with time-periodical boundary temperature which is independent of θ. In conclusion, author comments on the method and results of the work. K. Rektorys, Czechoslovakia

2586. Trimpi, R. L., and Jones, R. A., Transient temperature distribution in a two-component semi-infinite composite slab of arbitrary materials subjected to aerodynamic heating with a discontinuous change in equilibrium temperature or heat-transfer coefficient, *NACA TN* 4308, 29 pp. + 2 tables + 9 figs., Sept. 1958.

A heat-conduction problem of interest in connection with aerodynamic heating is treated by Laplace transforms. The solution is obtained as a series of functions of x and t defined by integrals. An extensive tabulation of the first six functions and their derivatives with respect to x and t is included.

W. Squire, USA

2587. Camia, F., Ballistic curves of heat and diffusion in a cylinder of finite radius and for the case of radial flux: fundamental equations (in French), *C. R. Acad. Sci., Paris* **245,** 25, 2218–2221, Dec. 1957.

Familiar Fourier-Bessel type of series solution is expressed in a form that can be applied to a variety of boundary conditions.

S. Paterson, Scotland

2588. Karavaev, N. M., and Stel'makh, G. P., The influence of internal thermal resistance of a body on heat transfer (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 2, 36–42, 1957.

Authors consider the heat exchange between a body and a moving medium and also the influence of the internal thermal properties of the body on the surface coefficient of heat transfer and the total coefficient of heat transfer. In the classical cases of the phenomenon in question authors evaluate the correction factor which takes into account the difference between the internal thermal resistance during the heat transfer of an ideal body (infinitely large thermal conductivity) and of a real body. This correction factor may be applied when one calculates the time of heating or cooling of real bodies or when one evaluates the thermal balance of a real system with the corresponding magnitudes for an ideal system being known. The time of a heating of a material body depends upon the coefficient of heat transfer between the surface and the center of the body as well as upon the intensity of the transfer of the heat towards the inside of the body. The surface coefficient of the heat transfer depends fundamentally also upon the hydrodynamic conditions of the phenomenon of the flow around this body. Actually the whole analysis is based upon the Fourier heat equation. The results are presented in a graphical form. M. Z. v. Krzywoblocki, USA

2589. Korenev, B. G., Stationary temperature field in a thin plate or rod, lying on a continuous homogeneous foundation (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **107,** 2, 225–228, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8184.

By means of methods worked out in the statics of plates on an elastic foundation the problem is investigated of the stationary temperature field in an unbounded thin homogeneous isotropic plate and in a rod of infinite length, lying on a homogeneous foundation. The designation "homogeneous foundation" is given to a foundation having an upper bounded surface where, under the action of an accurate source applied to the point (ξ,η) of the upper boundary, the temperature in point (x, y) of the upper boundary will only be a function of amplitude r

$$t = k(r) \qquad (r = \sqrt{(x-\xi)^2 + (y-\eta)^2})$$

A solution is advanced for various cases of distribution of heat sources on the plate. If the sources are evenly distributed on a straight line, coinciding with axis y, then the solution for the plate remains valid and also for a rectilinear rod of finite width and supported by a plate of the same thickness, if the lateral surfaces of the plate and rod form an adiabatic boundary.

V. G. Popkov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2590. Preckshot, G. W., and Gorman, J. W., Steady-state longitudinal and radial temperature distributions in internally heated finite wires, *Indust. Engng. Chem.* **50,** 5, 837–848, May 1958.

Cylindrical wires with an internal heat source distribution and transfer to a surrounding medium are treated analytically. Solution is obtained for the general problem with conduction in both radial and longitudinal directions, ends of wire at temperature of surrounding medium, and source distribution a linear function of temperature. Case of radial temperature variation only is considered, and that of only longitudinal variation is treated extensively with different simplifications and assumptions regarding dependence of heat source strength, surface heat-transfer coefficient, and therma conductivity on temperature. Longitudinal temperature distributior along a thin platinum wire at two maximum temperatures in boiling water is calculated for various assumptions.

Simple expressions for the ratio of the wire temperature at its mid-length to its average temperature and the ratio of the wire temperature at the ends of a central test section to its average temperature are obtained. J. E. Plapp, USA

2591. Serova, N. V., Calculation of thermal flows in the soil in wintertime (in Russian), *Tr. Gl. Geofiz. Observ.* no. 60 (122), 80–85, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10604.

A description is given of a new remote-operating apparatus with thermistors used as transmitters, intended for use in the measurement of the temperature of the upper layer of the soil. Field experiments, carried out in both expeditionary and stationary conditions, showed that, in comparison with analogous apparatus, the apparatus in question guarantees an increased precision of measurement for any arbitrarily chosen general range of temperatures being measured. On the basis of data on soil temperatures obtained by means of the apparatus described, and following G. Kh. Tseitin's formula [*Trudi Gl. Geofiz. Observ.* no. 60 (122), 1956], calculations were made of the flow of soil temperatures in wintertime, and for this purpose use was made of Z. A. Nersesov's curves ["Materials for laboratory investigations of frozen soils," Collection 2, 1954] for the determination of the thermal characteristics of frozen soils. The paper ends by giving examples of the calculations and of a series of qualitative deductions.

L. N. Gutman
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2592. Tsederberg, N. V., Heat conductivity of binary solutions (in Russian), *Teploenergetika* **3**, 9, 42–48, Sept. 1956.

2593. Seleznev, K. P., and Taranin, A. I., Determining temperature distribution in elements of gas turbines using electric models (in Russian), *Energomashinostroenie* no. 3, 8–12, Mar. 1956.

2594. Ragsdale, R. G., Heat-transfer and friction measurements with variable properties for airflow normal to finned and unfinned tube banks, *NASA Memo* 10-9-58E, 14 pp. + 2 tables + 10 figs., Dec. 1958.

Average heat-transfer and friction coefficients are reported for heat addition to air flowing normal to staggered banks of electrically heated finned and unfinned tubes for variable property conditions. The data are for Reynolds numbers from 2000 to 35,000 and surface-to-bulk temperature ratios from 1.07 to 2.36. The use of bulk density to evaluate Reynolds number is unsatisfactory. Single-line correlations are obtained by evaluation of specific heat, thermal conductivity, viscosity, and density at film and surface temperatures. From author's summary

2595. Levy, S., Fuller, R. A., and Niemi, R. O., Heat transfer to water in thin rectangular channels, ASME Ann. Meet., New York, N. Y., Nov.-Dec. 1958. Pap. 58-A-127, 12 pp.

Heat-transfer coefficients are presented for water flowing vertically in thin rectangular channels (0.1 × 2.5 in.) 18 and 36 in. long and heated electrically around the entire periphery. The range of variables covered is: 65 to 200 psia pressure, 90 to 200 F subcooling, and 4 to 50 fps water velocity. Heat-transfer correlations are given for data along the narrow and wide faces of the rectangular test section. Burnout data also are reported with steam blanketing occurring first at the corner of the test section. The proposed correlating equation, valid at the narrow face of the test section, gives values considerably lower than those obtained in a circular pipe. From authors' summary

2596. Rabinowicz, J., Measurement of turbulent heat transfer rates on the aft portion and blunt base of a hemisphere cylinder in the shock tube, *Jet Propulsion* **28**, 9, 615–620, Sept. 1958.

Measurements were made in 2-⅞ × 2-⅞-in. GALCIT shock tube at shock Mach numbers between 3.25 and 5.1 corresponding to flow Mach numbers between 1.25 and 1.5. Initial pressures were between 3 and 17 cm Hg; local Reynolds numbers on cylinder afterbody were between 3.5×10^4 and 3×10^5 per cm. Model was side-supported.

Measured turbulent heat-transfer rates on cylindrical portion agreed very well with previous flat plate measurements for small temperature differences, although ratio of stagnation to surface enthalpy varied between 3 and 8 in reported tests. The measured heat-transfer rate on the base indicated that at the center of the base the heat-transfer rate is comparable to that on the surface just ahead of the base, while the heat-transfer rate falls off to one half to one third of this value toward the rim of the base. This unexpected distribution of heat-transfer rate over the base, and particularly the high value at the center, shows the necessity for a careful study of wake phenomena.

From author's summary by E. Reshotko, USA

2597. Robinson, G. C., McClure, C. M., III, and Hendricks, R., Jr., Effects of ultrasonics on heat transfer by convection, *Bull. Amer. Ceram. Soc.* **37**, 9, 399–404, Sept. 1958.

An investigation was made on the effect of 400-kc sound waves on the temperature drop between heated air and a solid and between heated oil and a solid. It was found that ultrasonic energy can alter this temperature drop only when the fluid is capable of transmitting the sound energy. Several pieces of equipment were especially constructed for this investigation and the construction of the equipment is described. The equipment includes an air to solid heat exchanger, a liquid to solid heat exchanger, a device for coupling ultrasonic energy to high-temperature specimens, and a vibration pickup. From authors' summary

2598. Forstat, H., Length effect in the heat transport in helium II, *Phys. Rev.* (2) **111**, 6, 1450–1452, Sept. 1958.

A length effect in the heat transport in helium II in small channels has been observed. Measurements were made using a column of packed jeweller's rouge for lengths of 3.179, 5.166, and 8.156 cm in the temperature range 1.70–2.17 K. The channel size was approximately 0.1 micron. The results verified the linear dependence of the heat current density on temperature difference and showed a decrease in the heat transport by approximately a factor of 2 as the rouge length was increased from 3.179 to 8.156 cm.

From author's summary

2599. Carter, H. S., Effect of some external crosswise stiffeners on the heat transfer and pressure distribution on a flat plate at Mach numbers 0.77, 1.39, and 1.98, *NACA TN* 4333, 11 pp. + 1 table + 9 figs., Sept. 1958.

The investigation was made in a free jet for Reynolds numbers from 3×10^6 to 14×10^6, based on a length of 1 foot. The addition of external crosswise stiffeners to the flat-plate models caused large pressure and heat-transfer variations on the surfaces of the models. From author's summary

2600. Sands, N., and Jack, J. R., Preliminary heat-transfer studies on two bodies of revolution at angle of attack at a Mach number of 3.12, *NACA TN* 4378, 13 pp. + 5 tables + 10 figs., Sept. 1958.

Heat-transfer rates were studied on a cone cylinder and a parabolic-nosed cylinder at angles of attack up to 18°. Data were obtained for the initially cooled models at Reynolds numbers of 6.8×10^6 and 12.0×10^6 based on model length. For similar type boundary layers Stanton numbers at angles of attack were always higher than those of corresponding geometric location and test conditions at zero angle of attack. On the windward side Stanton numbers increased steadily with increased angle of attack. Along the most leeward generator no systematic variation of Stanton number with angle of attack was found. The parabolic forebody had two advantages over the conical forebody: it delayed transition and reduced local Stanton numbers.

From authors' summary

2601. Deissler, R. G., and Taylor, M. F., Analysis of turbulent flow and heat transfer in noncircular passages, *NACA TN* 4384, 24 pp. + 9 figs., Sept. 1958.

In a previous paper [AMR **7** (1954), Rev. 3721], the senior author calculated distributions of velocity and temperature for fully developed turbulent flow in a circular tube by assuming the eddy diffusivity to be proportional to the velocity and distance from the wall in the region close to the wall and given by von Karman's expression in the region away from the wall. The eddy diffusivities for momentum and heat were assumed equal. In the present investigation, calculations are carried out graphically to determine flow and heat transfer in passages having square and equilateral triangular cross sections by assuming the previously calculated nondimensional distributions of velocity and temperature to apply along lines normal to the wall. Velocity distributions, wall shear-stress distributions, and friction factors, as well as wall heat-transfer distributions, wall temperature distributions, and average heat-transfer coefficients, are calculated for Reynolds numbers from 2×10^4 to 9×10^5 and Prandtl numbers from 0.73 to 300. Calculated results show that velocities, shear stresses, and heat transfer in the region near the corner are lower than average values and are zero at the corner. Friction factors and average Nusselt numbers are lower than in a circular tube. Calculated results are in reasonably good agreement with experimental data, although the slight discrepancies at higher Reynolds numbers seem to be caused by secondary flow or peripheral heat transfer, both of which are neglected in the analysis.

I. Tani, Japan

2602. Sugawara, S., Sato, T., Komatsu, H., and Osaka, H., The effect of free-stream turbulence on heat transfer from a flat plate, *NACA TM* 1441, 8 pp. + 13 figs., Sept. 1958.

Paper is a translation of "Shuryubu midare ga heiban nets udentatsu ni oyobosu likyo ni tsuite," *J. Japan. Soc. Mech. Engng.* **19,** 18, 18-25, 1953.

The effect of free-stream turbulence on the heat loss from a flat plate in an airstream was investigated by suspending a plate in the turbulent flow behind a square-mesh grid. Over the range of Reynolds numbers 9000 to 300,000, free-stream turbulence increases the local coefficient of heat transfer by a constant factor (dependent on the turbulent intensity) provided that the boundary-layer flow is turbulent without the added turbulence from the grid. If the stream turbulence exceeds 7-8%, no further increase of heat transfer occurs and the heat transfer remains constant at 1.55 times the value for no stream turbulence. Detailed measurements of the turbulent fluctuations are described.

A. A. Townsend, England

2603. Harkness, J. L., Heat transfer investigations in supersonic flow, AFOSR TR 58-21 (Univ. Texas Defense Res. Lab. DRL 429; ASTIA AD 152 023), 29 pp. + 37 figs., Mar. 1958.

The major effort concerns the development of a small high stagnation temperature intermittent-flow supersonic wind tunnel; a description of this work and the resulting facility is presented. The development of an electrically heated shield temperature probe, for measurements in supersonic flow, is described and the results of an interference study, concerning total pressure probes in the boundary layer, are presented. Heat-transfer measurements on a flat-plate model were accomplished and this investigation is described including a brief discussion of the test results. An analytical study concerning the temperature distribution through the turbulent boundary layer is also discussed. All of this work has been previously reported in considerable detail and specific references are given in each case.

From author's summary

2604. Harkness, J. L., Heat transfer measurements on a flat plate model at Mach number 5.0, AFOSR TN 58-74, (Univ. Texas Defense Res. Lab. DRL 423; ASTIA AD 148 118), 23 pp. + 12 tables + 18 figs., Jan. 1958.

Report presents the results of heat-transfer measurements made on a flat plate model in a 6 × 7-inch wind tunnel at a free-stream Mach number of 5.05. The internal surface of the model was cooled and the heat-transfer rate was determined by measuring the temperature drop across the model once temperature stabilization was achieved. A general description of the wind-tunnel facility used is presented as well as a complete description of the design and construction details of the heat-transfer model. The results of the tests are discussed and the data are presented both in tabular form and on plots for comparison with existing theories. Some laminar data were obtained but in most cases the flow over the model was largely turbulent. It is concluded that the turbulent theory of Van Driest is at least 15% below the true values.

From author's summary

2605. Bradfield, W. S., Hanson, A. R., Sheppard, J. J., and Larson, R. E., A technique for experimental investigation of heat transfer from a surface in supersonic flow at large surface-to-free-stream temperature ratios, AFOSR TR 58-64 (Rosemount Aero. Labs., Univ. Minn. Inst. Technol. Res. Rep. 150; ASTIA AD 158 252), 11 pp. + 13 figs., June 1958.

A description is given of an experimental technique for studying heat transfer at high temperatures. The direction of heat flux is from the surface to the boundary layer. Preliminary values of local convective and radiative heat transfer are reported. Some data are given on the deterioration of graphite surfaces coated with silicon nitride and silicon carbide.

From authors' summary

2606. Monaghan, R. J., A survey and correlation of data on heat transfer by forced convection at supersonic speeds, *Aero. Res. Counc. Lond. Rep. Mem.* 3033, 31 pp. + 31 figs., 1958.

This report surveys and, wherever possible, correlates experimental data available in the United Kingdom up to January 1953 on heat transfer by forced convection to bodies moving through the air at supersonic speeds (or the corresponding wind-tunnel problem). The main aim of the investigation was to seek possible explanations for the occasional apparent inconsistencies between wind-tunnel results from different sources, between wind-tunnel and flight results and between either type of experimental results and the predictions of theory.

The main topics covered are kinetic temperature rise, heat-transfer coefficients and transition from laminar to turbulent flow.

Conclusions are reached concerning the reliability of the data for design purposes and suggestions are made concerning the most useful fields of study for future experimental work.

A considerable amount of further evidence has become available in the years since 1953 and in places it is necessary to amend some of the statements made in this report. This has been done by adding footnotes prefixed by the date 1956.

From author's summary

2607. van Driest, E. R., On the aerodynamic heating of blunt bodies, AFOSR TN 57-732 (North Amer. Aviation, Inc., Missile Devel. Div. Rep. MD 58-6; ASTIA AD 136 716), 14 pp. + 17 figs., Nov. 1957.

Calculation of the heating rate for blunt bodies in high-speed flight, including the phenomenon of transition, is discussed. Analysis of the problem with transpiration cooling is presented.

From author's summary

2608. Mirzadzhanzade, A. Kh., and Abassov, A. A., Approximate solution of the problem of heat exchange when a structural regime of motion of a viscous-plastic liquid in a round cylindrical tube is in operation (in Azerb.), *Dokladl Akad. Nauk AzerbSSR* **12,** 3, 155-161, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 7996.

The distribution is found approximately of the temperature in a viscous-plastic liquid flowing in a round cylindrical tube at a given temperature at the wall and in the first section. The parameters of the liquid are assumed to be independent of the temperature. The equation of heat transfer is recorded in the viscous-plastic and plastic regions (the term containing the expression $\partial^3 T/\partial x^3$ is dropped, and dissipation is disregarded). After division of the variables, equations are obtained for the radial distribution of temperature in each of the regions. These equations are solved by Ritts' method, at the same time the functions are given in the form of polynomes in even steps r up to the fourth order. Formulas are obtained giving the approximate temperature distribution in both regions of the flow. The results are not discussed.

B. Z. Gershuni

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2609. Haas, A., Determination of the heat-convection coefficient by the schlieren procedure (in Hungarian), *Meres es Automat.* **6**, 5/6, 138–144, May/June 1958.

2610. Beckwith, I. E., The effect of gas properties on the heat transfer in stagnation flows, *J. Aero/Space Sci.* **25**, 8, 533–534 (Readers' Forum), Aug. 1958.

2611. Hammitt, F. G., Natural-convection heat transfer in closed vessels with internal heat sources—analytical and experimental study, ASME Ann. Meet., New York, N. Y., Nov.-Dec. 1958. Pap. 58-A-212, 13 pp.

The phenomenon of natural-convection heat transfer and fluid flow in closed vessels with heat sources internal to the fluid has assumed importance in connection with homogeneous nuclear reactors. It is also prominent in various chemical processes. Natural convection, in the absence of internal-heat sources perhaps under the impetus of an intensified body force, is important also in various applications. This paper presents the results of an experimental and analytical study on vertical, cylindrical closed cells, containing fluid in which heat is generated internally. The heat is removed through the container walls to maintain steady state. As a special case the analysis is applicable to the condition of no internal heat generation; rather replenishment through open access at one end to an infinite reservoir. It gives a basis for engineering estimates of temperature differentials, velocities, and heat fluxes.

From author's summary

2612. Byzova, N. L., Theory of self-exciting oscillations of heat convection (in Russian), *Trudi Mor. Gidroviz. In-ta Akad. Nauk SSSR* no. 6, 80–97, 1955; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4395.

Examination of the flow in a plane horizontal layer with a free surface. The temperature gradient is constant along the layer. A form of equation for the mean velocity in the lower and upper parts of the flow was found on the assumption that the velocity profile is more or less steady. The equation contains an empirical coefficient and connects velocity and temperature changes. The amplitude of the oscillations of temperature in the layer near the bottom at given velocity oscillations is evaluated with the aid of the heat-conduction equation. It is noted that there is a satisfactory correspondence with experimental values. An examination is made of the propagation of heat disturbances in a rectilinear moving flow having constant velocity over the section. First there is a discussion of the two solutions of the equation of thermal conduction which describes the propagation of the disturbances in conditions of absence of a supply of heat. There is no mechanism here which maintains the oscillations and they die away. Examination of the general case leads to finding the condition of undamped oscillation. Since an unknown function is introduced into this relationship and it characterises the supply of heat to the system, no success was obtained in coming to any theoretical conclusions from analysis of this relationship.

E. M. Zhukhovitskii

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Translation, courtesy Ministry of Supply, England

2613. Mirels, H., Flat plate laminar skin friction and heat transfer in the free molecule to continuum flow regimes, *Jet Propulsion* **28**, 10, 689–690 (Tech. Notes), Oct. 1958.

Previous solutions of Rayleigh's problem (impulsive start of a flat plate) using continuum equations with slip boundary conditions estimated skin friction and heat transfer inaccurately due to the choices made of the constant in the transformation from time to downstream distance.

Author's approach replaces time by distance and modifies all numerical constants to provide agreement in the limits of free molecule and continuum flow, yielding expressions for semi-infinite flat plate shear and heat transfer more valid over the complete range of free molecule to continuum flow. The general relations for wall drag coefficient and heat flux are given, also special solutions for viscosity proportional to absolute temperature and specific heat ratio = 1.4.

The wall temperature is assumed constant in these solutions. A major deficiency is that the low-speed model used does not take into account boundary-layer-induced modifications of the free stream. This method also underestimates the wall shear in the border regime between continuum and slip flow.

C. F. Bonilla, Puerto Rico

2614. van Driest, E. R., On mass transfer near the stagnation point, AFOSR TN 57-458, (North Amer. Aviation, Inc., Missile Devel. Div. Rep. AL-2553; ASTIA AD 136 449), 8 pp. + 12 figs., June 1957.

Heat transfer with blowing near the stagnation point is computed by first analyzing the problem for the flat plate without pressure gradient and then converting the solution to that for the stagnation region of spheres and cylinders.

From author's summary

2615. Thompson, G. V., How to calculate thermal radiation from hot surfaces, *Prod. Engng.* **29**, 13, 116–117, Mar. 1958.

2616. Forster, K. E., and Greif, R., Heat transfer to a boiling liquid; mechanism and correlations, ASME-AIChE Joint Heat Transfer Conf., Chicago, Ill., Aug. 1958. Pap. 58-HT-11, 33 pp.

A satisfactory theory of the mechanism of nucleate boiling heat transfer is necessary for the calculation of heat flux for various conditions. Authors review existing theories and propose another, a "vapor-liquid exchange" mechanism. They present evidence, notably the effects of subcooling and of bulk velocity, in support of this proposal. Correlations developed by the authors from this mechanism are shown to be in good agreement with experimental data. No effects of variation in surface properties are considered.

In essence the theory contends that heat transfer in nucleate boiling is accomplished by the movement of the hot liquid, which occupied the bubble volume, into the main stream when the bubble grows; and replacement by cold liquid when the bubble collapses or separates. This is similar to the mechanism proposed in other applications, e.g., *Chem. Engng. Sci.* **3**, 209–214, 1954, wherein (1) a mass of liquid is brought into contact with a surface, (2) the fluid in contact with the surface assumes the surface temperature and transfer occurs into the mass, (3) the mass of fluid moves away from the surface and is replaced by another.

C. E. Sanborn, USA

2617. Fuks, N. A., On the theory of the evaporation of small droplets, *Soviet Phys.-Tech. Phys.* **3,** 1, 140–143, Aug. 1958. (Translation of *Zh. Tekh. Fiz., Akad. Nauk SSSR* **28,** 1, 159–162, Jan. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

Author derives a formula for the rate of evaporation I of droplets, valid for any ratio of mean free path to droplet radius r:

$$I = I_0 \left[(D/\nu\nu\,\alpha) + r/r + \Delta\right]^{-1}$$

where D is the diffusion coefficient, α the evaporation coefficient, Δ the distance from the drop surface to the first collision of the evaporating molecules, ν is ¼ of the mean speed of a vapor molecule or $(kT/2\pi m_1)^{1/2}$, and $I_0 = 4\pi rD\,(c_0 - c_\infty)$, Maxwell's formula for the rate of evaporation of a spherical droplet for λ/r negligible.

The equation agrees with Birks and Bradley's experiments with dibutylphthalate droplets of $r = 0.5$ mm in air down to 0.01 cm of Hg, or $\lambda/r \sim 1$. To establish the relation, more accurate tests and high ratios of λ/r are required.

C. F. Bonilla, Puerto Rico

2618. Scala, S. M., Vaporization into a hypersonic laminar boundary layer, *J. Aero/Space Sci.* **25,** 10, 655–656 (Reader's Forum), Oct. 1958.

Boundary conditions are presented for the interface between the gas phase and the condensed phase in a hypersonic dissociated boundary-layer flow over a vaporizing surface. The rate of evaporation is assumed determined by the equilibrium vapor pressure, and independent of the partial pressure in the gas phase, and the condensation rate is assumed proportional to the partial pressure. An expression for interphase mass transfer, by convection and diffusion, is given and particular results are cited for the forward stagnation point of a blunt body. It is pointed out that in solving the boundary-layer equations the rate of vaporization may be overestimated if one assumes simply that the equilibrium vapor pressure is equal to the partial pressure, rather than determining the vapor pressure from, say, the Clausius-Clapeyron equation and computing the actual partial pressure from the surface vaporization coefficient and the interface boundary conditions.

L. Talbot, USA

2619. Borman, G. L., El Wakil, M. M., Uyehara, O. A., and Myers, P. S., Graphs of reduced variables for computing histories of vaporizing fuel drops, and drop histories under pressure, *NACA TN* 4338, 28 pp. + 1 table + 18 figs., Sept. 1958.

A simplified calculation technique is developed for the vaporization of sprays in a gas, of value in the design of combustors.

The results are obtained in the form of graphs of percent evaporated against reduced time, and the liquid temperature versus reduced time as a function of air temperature. Such curves are shown to be general, provided the initial temperature of the liquid is below a reasonable critical value (e.g. 550R for hexane in air at 800 to 1600R). Reasonable accuracy is obtained.

Steady-state temperatures of hexane, decane and hexadecane were determined experimentally at 1 to 5 atmospheres absolute, agreeing within 10F with the predicted values.

C. F. Bonilla, Puerto Rico

2620. Herrington, L. P., Full-scale human-body-model thermal exchange compared with equational condensations of human calorimetric data, ASME Ann. Meet., New York, N. Y., Nov.-Dec. 1958. Pap. 58-A-181, 9 pp.

Reliable instruments which have advanced knowledge of biothermal heat exchange are the human calorimeter and heated models of the human body. Both instruments provide excellent data on a heat exchanger characterized by thermal-feedback alteration of conductance, evaporative process, and heat production. These bioengineering properties combined with complex shape, variable compound insulation, and a wide range variation of possible ambient exposures, vastly complicate the strict application of the rational heat-exchange equations established in thermal-engineering practice. From author's summary

2621. Diehl, J. E., and Unruh, C. H., Two-phase pressure drop for horizontal cross flow through tube banks, ASME-AIChE Joint Heat Transfer Conf., Chicago, Ill., Aug. 1958. Pap. 58-HT-20, 9 pp.

Air-water and pentane liquid-vapor mixtures were blown across two staggered and two in-line multitube arrangements. Most data were limited to liquid volume fractions higher than 85%. The ratio of total pressure drop to pressure drop of gas phase (similar to the Martinelli parameter) correlated all the data fairly well against a parameter LVF (liquid volume fraction) divided by the ratio of gas to liquid densities. Reviewer finds that the correlations, particularly the one for 45° staggered tubes, are close to curves obtained for homogeneous flow showing little effect of slip between phases.

Authors extend these curves to the case of changing LVF, i.e. condensation, and results compare within 30% predicted pressure drops with measurements on a pentane condensing system. Reference is made to a previous paper on the subject with vertical flow.

M. A. Santalo, Mexico

2622. Glikman, B. F., On the condensation of a steam jet in space filled with a liquid (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 2, 43–48, 1957.

Paper deals with the theoretical solution of the problem of condensation of a plane steam jet in the space filled out by a liquid at rest. Writer evaluates the location of the surface condensation as depending upon the parameters of the steam and velocity; he also calculates the velocity pattern in the jet. The fundamental equation governing the velocity distribution is a third-order ordinary differential equation derived by G. N. Abramovich ["Free turbulent jets of liquids and gases," GZI, 1948]. The solution is found in terms of exponential and trigonometric functions with coefficients determined from the boundary conditions. The results show that in a jet with a surface condensation the losses of the kinetic energy are greater than in ordinary jets.

M. Z. v. Krzywoblocki, USA

2623. Mirzadzhanzade, A. Kh., and Dzhalilov, K. N., Approximate solution of Stefan's single-dimensional problem (in Russian), *Zh. Tekh. Fiz.* **25,** 10, 1800–1803, 1955; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10711.

An approximate solution of Stefan's problem is presented for a semi-bounded rod at constant initial and boundary temperatures (this problem deals also with the examination of various questions concerned, particularly, with filtration problems). Here author utilizes M. E. Shvets' method, based on the introduction of some zone of influence having a finite length $L(t)$ [*Prikl. Mat. Mekh.* **13,** no. 3, 1949]. This method, even at its first approximation, gives results close to the known exact solution of the given problem.

N. N. Verigin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2624. Gadzhieva, M. G., Regarding an approximate method of solution of the single-dimensional problem set by Stefan (in Russian), *Uch. Azerb. In-ta* no. 4, 3–5, 1955; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10712.

An approximate solution of Stefan's problem is given for a semibounded rod with the same initial temperature everywhere and with a constant flow of heat on the end of the rod. The method of solution is the same as that proposed by A. Kh. Mirzadzhanzade and K. N. Dzhalilov [see preceding review]. In the paper being

reviewed, the physical purport of the condition $L(0) = m$ is not explained and there are misprints in Eqs. [2] and [7].

N. N. Verigin
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2625. Winkler, K., A graphical procedure for the design of heat exchangers (in German), *Radex-Rundschau* no. 2, 63–71, Mar. 1958.

If heat transfer from a hot fluid is plotted as function of wall temperature, and if similarly the heat absorption of cold fluid is plotted as function of the same variable, the point of intersection of the loci yields the correct wall temperature, and so the proper rate of heat exchange. This simple continuity principle (heat removed from one fluid = heat added to another) is applied to the fairly complex example of a coaxial chimney-type exchanger where effectively three walls of different temperature distributions (core, exchange wall, and exterior wall) are present. In a detailed numerical and graphical calculation clearly separating radiation and convection effects, the required length of the exchanger is computed. W. Hitschfeld, Canada

2626. Rose, P. H., Development of the calorimeter heat transfer gauge for use in shock tubes, *Rev. Sci. Instrum.* **29,** 7, 557–564, July 1958.

A heat transfer gage is described in which a relatively thick metal element is employed as a calorimetric pick-up for measuring high heat flux, such as obtained in shock tubes. The resistance history of the gage element, obtained from oscillograms, is related to the heat flux by average gage temperature. Calibration is required to determine actual physical properties of gage material used. Effects of temperature distribution through the gage, losses at the boundary, gage geometry, and measuring errors have been given consideration. H. M. Spivack, USA

2627. Pott, F. Ph., A method for the determination of the thermal conductivity of small probes at high temperatures (in German), *Z. Naturforsch.* **13a,** 2, 116–125, Feb. 1958.

An experimental technique is presented for the determination of the thermal conductivity of thin metal strips over a wide range of temperatures. The sample is heated by passing an electric current through it and the temperature measured precisely by means of thermocouples. By controlling the state of the surroundings, and by use of two different heating rates, it is possible to correct for the radiation losses. Further small corrections for thermocouple error and heat conduction are also made. Results are shown for copper which agree closely with the values obtained by Schofield using a guarded heat plate method. The great advantage of this method lies in the small sample size needed, but the accuracy is estimated at only about ±4%. R. V. Dunkle, USA

Combustion

(See also Rev. 2255)

2628. Ziemer, R. W., and Cambel, A. B., Flame stabilization in the boundary layer of heated plates, *Jet Propulsion* **28,** 9, 592–599, Sept. 1958.

An increase in surface temperature of a plate in a combustible flow field will increase the flame velocity near the plate, increase the boundary-layer thickness along plate, and decrease the quenching distance. These changes allow stabilization at a higher free-stream velocity. From a knowledge of the individual effects, a graphical analysis is given which determines the position of the flame on the plate. This analysis is verified with propane-air flames. I. Glassman, USA

2629. Talantov, A. V., Velocity of propagation of a flame and propagation of the combustion zone into a turbulent flow (in Russian), *Tr. Kazansk. Aviats. In-ta* **31,** 157–168, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10021.

The turbulent combustion of a homogeneous mixture is investigated and an attempt is made to develop and to make more precise the presentation of the problem by K. I. Shchelkin [*Zh. Tekhn. Fiz.* **13,** 1943]. For the case of a feeble turbulence ($w'/u_N < 1$, where w' is the pulsation velocity, u_N the normal velocity of the flame's propagation) a formula is obtained as the result of geometrical analysis $u_R = u_N + w'$, where u_R is the velocity of propagation of the turbulent flame. For the case of strong turbulence ($w'/u_N > 1$)

$$u_R = u_N + Aw'/[\ln (1 + w'/u_N)]^{1/2}$$

where A is a dimensionless coefficient of the order of unity. It follows from this correlation, as opposed to the result obtained by Shchelkin ($u_R \sim w'$), that value u_T depends on the normal velocity u_N even when there is very strong turbulence. Additional precision is reached on the assumption that the combustion of the gram-molecule of the fresh mixture from the surface proceeds not with velocity u_N but with a larger velocity, conditioned by the pulsation effect, leading to the curvature of the flame's surface and to a corresponding increase. Formulas are given to determine the extension of the combustion zone and the rate of burning of the molecule. V. E. Doroshenko
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2630. Grumer, J., Flashback and blowoff limits of unpiloted turbulent flames, *Jet Propulsion* **28,** 11, 756–758 (Tech. Notes), Nov. 1958.

New data are presented for laminar tilted flame limits, turbulent flashback limits, and turbulent blowoff limits of unpiloted flames of natural gas-air mixtures. Flashback gradients for turbulent flames and tilted flashback gradients for laminar flames of the same fuel-air composition were found to be approximately identical for hydrogen-oxygen mixtures using very narrow burner tubes. These limits were not identical for slower burning natural gas-air flames on much larger burners. The author suggests that the laminar boundary sublayer of small diameter ports is more effective in producing flashback than the sublayer of wide diameter ports. Turbulent flashback in wide diameter ports may otherwise be caused by conditions in the core of the turbulent stream.

Blowoff gradients of unpiloted pipe flow turbulent flames also show that stabilization of turbulent flames is not always caused by events in the laminar boundary sublayer; contrary evidence is cited. Flame stability gain by expanded skirts at the burner port is described. J. M. Singer, USA

2631. Spakowski, A. E., The thermal stability of unsymmetrical dimethylhydrazine, *NASA Memo* 12-13-58E, 6 pp. + 1 table + 4 figs., Dec. 1958.

The self-ignition and spontaneous decomposition temperatures of unsymmetrical dimethylhydrazine were determined at atmospheric pressure to be 454 and 740 F, respectively. The larger value (740F) was obtained in an inert atmosphere of nitrogen and represented the minimum temperature that would cause a rapid exothermic reaction. The addition of 40 weight percent diethylenetriamine to pure unsymmetrical dimethylhydrazine did not significantly affect these properties. From author's summary

2632. Branstetter, J. R., Thermodynamic considerations of metal containing fuels for jet aircraft, ASME Ann. Meet., New York, N. Y., Nov.-Dec. 1958. Pap. 58-A-261, 24 pp.

A search is being conducted by a number of organizations for a fuel having a substantially higher heat of combustion than hydrocarbon fuels or for a fuel with a high thrust potential. The present paper attempts to show the relation between the thermodynamic

behavior of the combustion products and aircraft performance. The theoretical performance of several promising fuels and a conventional petroleum fuel are compared. Numerous practical considerations pertinent to the selection of a fuel are included.

From author's summary

2633. Zucrow, M. J., and Osborn, J. R., An experimental study of high-frequency combustion pressure oscillations, *Jet Propulsion* **28,** 10, 654–659, Oct. 1958.

Premixed gaseous propellants (hydrogen, methane, ethane, ethylene, or propane and air) have been injected into an instrumented rocket combustion chamber of 3.375-in. diameter and variable length, to 28 inches. Nozzle size and shape and equivalence ratio have also been varied, and effects upon high-frequency combustion pressure oscillations have been studied. The apparatus is described, as well as trends in the data, and a few sample oscillograph records are shown, but detailed results are not presented. Combustion-chamber pressure was varied in the range from 25 to 130 psia, peak-to-peak oscillation amplitudes being as large as 35 psi in one case. Wave shape varied from a sinusoidal to a shock type. The longitudinal mode was found to occur only when the chamber length exceeded two or three diameters, at 45 psia. However, increase of pressure caused a shift from longitudinal to transverse modes, at a given chamber length. Nozzle shape affected wave shape. Instability regions are plotted as a function of equivalence ratio and pressure, for various fuels. A tentative theoretical interpretation of the results is offered, involving a type of detonation wave. L. Crocco [*Jet Propulsion* **28,** p. 843, Dec. 1958] has published some interesting comments on the theoretical aspects of this paper. R. Friedman, USA

2634. Jonash, E. R., Wear, J. D., and Cook, W. P., Effect of fuel variables on carbon formation in turbojet-engine combustors, *NACA Rep.* 1352, 18 pp., 1958.

Three empirical fuel factors (smoke-volatility index, smoke point, and NACA K factor) satisfactorily correlated combustor deposit and exhaust-gas smoke data obtained at one operating condition in a single tubular turbojet combustor and in several full-scale engines. None satisfactorily correlated data obtained at a higher pressure and temperature condition in the single combustor. A number of organometallic compounds, commercial additives, and oxygen-bearing compounds markedly reduced deposits in the single combustor. The most effective additive, dicyclopentadienyliron, reduced base-fuel deposits approximately 80%. None of the additives affected exhaust-gas smoke.

From authors' summary

2635. Pavlov, S. M., and Tyutin, M. S., Study of mass exchange in flames by means of a helium flowfinder (in Russian), *Pribory i Tekhn. Eksperimenta* no. 2, 92–94, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10030.

A description is given of an experimental investigation of mass exchange in flames by mixing some helium into the burning gas and determining the fields of concentration of the helium in the zone of flame being examined. To avoid distortion in the aerodynamic structure of the jet of flame the tests were carried out in a special gas tube, with outer diameter of 1.5 and inner diameter 1.00 mm at a velocity of 0.4 m/sec. Analysis for helium content of the tests was carried out in the simplest way by mass-spectrum-helium flowfinder PTI4A. A. B. Reznyakov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2636. Bittker, D. A., An analytical study of turbulent and molecular mixing in rocket combustion, *NACA TN* 4321, 13 pp. + 7 figs., Sept. 1958.

Fuel and oxidant mixing are analyzed on supposition of uniform axial velocity and uniform eddy diffusivity, injected streams acting as point sources. With assumed diffusivity values, author concludes that molecular diffusion is unimportant, and that turbulent mixing is usually fast compared with droplet vaporization, though not negligible.

Reviewer remarks that analysis is illuminating but that effective diffusivity needs to be measured in actual rockets (e.g. by tracer technique) before conclusions of paper can be relied on.

D. B. Spalding, England

2637. Chesters, J. H., The aerodynamic approach to furnace design, ASME Ann. Meet., New York, N. Y., Nov.–Dec. 1958. Pap. 58-A-72, 9 pp.

Flow patterns and mixing in actual furnaces can be best appreciated by starting with free jets and proceeding via jets in simple envelopes to jets (cold or alight) fed with surrounding air streams and impacting on surfaces. The fuel stream in an open-hearth furnace behaves initially as a free jet, entraining the relatively low velocity air around it, but on hitting the bath it splashes and runs forward and up the side walls. The gases reaching the roof eject flux droplets and then divide, part recirculating to meet the oncoming air and part joining the main flow to the exit. Future progress requires more knowledge of droplet dynamics, and demands more symmetrical flow, control of recirculation, or radical changes.

From author's summary

2638. Putnam, A. A., and Ungar, E. W., Basic principles of combustion-model research, ASME Ann. Meet., New York, N. Y., Nov.–Dec. 1958. Pap. 58-A-73, 6 pp.

The use of models to study problems encountered in the design of commercial and industrial combustion equipment is less well known than the use of their counterparts for aeronautical, hydraulic, erosion, and similar studies. The basic assumptions upon which cold-flow modeling of combustion systems is carried out, the application of modeling to various combustion problems, and the type of results that should be expected from the application of modeling techniques are discussed.

From authors' summary

Prime Movers and Propulsion Devices

(See also Revs. 2632, 2633)

2639. Mludek, H., and Schirrmeister, D., Thermodynamic computation of the high pressure turbine stages with help of digital computers (in German), *Technik* **13,** 11, 747–752, Nov. 1958.

2640. Goodger, E. M., Water injection in the normally-aspirated piston engine, *Coll. Aero. Cranfield Note* 78, 16 pp. + 20 figs., Mar. 1957.

2641. Orlin, A. S., Investigating the gas exchange in two-cycle engines (in Russian), *Energomashinostroenie* no. 9, 13–14, Sept. 1956.

2642. Arens, M., A comparison of turbojets and ramjets for high speed flight, *Jet Propulsion* **28,** 9, 620–621 (Tech. Notes), Sept. 1958.

2643. Schnitzer, H. C., Turbojet-engine mechanical design for high Mach number flight, *Aero/Space Engng.* **17,** 9, 35–39, Sept. 1958.

2644. Allen, R. W., Turbojet, turboprop, and reciprocating compound powered airplane transport systems, *Aero/Space Engng.* **17,** 9, 40–43, 48, Sept. 1958.

2645. Hyatt, A., Some effects of high-energy fuels on aircraft performance, *Aero/Space Engng.* **17,** 11, 45–50, Nov. 1958.

2646. Sloop, J. L., Rocket propulsion requirements for satellites and moon missions, *Aero/Space Engng.* **17,** 11, 36–44, Nov. 1958.

2647. Kappus, P. G., Air-breathing power plants in the space era, *Aero/Space Engng.* **17,** 11, 62–65, 69, Nov. 1958.

2648. Demetriades, S. T., Upper atmosphere atomic-oxygen power plant, *J. Aero/Space Sci.* **25,** 10, 653–654 (Reader's Forum), Oct. 1958.

2649. Greenwood, S. W., and Carton, D. S., Atmosphere breathing engines in astronautics. Part I: Flight in the earth's atmosphere; Part II: Flight in the atmosphere of other planets, *Coll. Aero. Cranfield Rep.* 88, 17 pp. + 11 figs., Oct. 1958.

The contents of this note fall into two sections. Part I considers the possibilities and problems involved in using ramjets as a power source for one of the stages of a satellite launching vehicle or similar project. In comparing such a system with rocket-powered vehicles, consideration is given to both performance and mass of the various systems. Various trajectories are considered. This work includes a reassessment of projects that have been suggested elsewhere.

The second part examines the possibility of using forms of ramjet in the atmosphere of other planets. Because there is insufficient knowledge of these atmospheres, a study has been carried out to determine the approximate performance of a chemical ramjet in atmospheres of methane, ammonia, hydrogen and carbon dioxide at Mach 3. The work in part II is original, there being no previously reported papers on the subject known.

These studies, which are necessarily based on several simplifying assumptions, indicate that applications for these engines may be expected to arise in astronautics, and that this is a fruitful field for further studies. From authors' summary

2650. Lawrence, H. R., and Amster, W. H., Reliability achievement and demonstration in a development program, *Aero/Space Engng.* **17,** 10, 65–69, Oct. 1958.

A program is outlined for improvement and demonstration of the reliability of liquid rocket propulsion systems and similar equipment using development test data.

From authors' summary

2651. Farber, M., Thermodynamics of Al_2O_3, *Jet Propulsion* **28,** 11, 760–761 (Tech. Notes), Nov. 1958.

Magneto-fluid-dynamics

2652. Spitzer, L., Jr., The stellarator concept, *Phys. Fluids* **1,** 4, 253–264, July–Aug. 1958.

All the work dealing with the attainment of economic nuclear fusion and actively under way since about 1950 has recently been declassified. Project Matterhorn, located in Princeton, has been concerned with a discharge in a torus. High-temperature plasma is confined by means of a magnetic field. In order to avoid certain types of instability, the longitudinal lines of force produced by an external coil are spirally twisted in a prescribed way. The resulting device, known as the stellarator, had originally a figure-8 form, but later it proved possible to return to a single torus on producing an equivalent twist by means of auxiliary coils. After initial breakdown, complete ionization of the gas and heating is produced by a longitudinal electric current. Since this was found to have certain drawbacks, other methods of heating such as resonance absorption of microwaves are under active investigation.

The paper under review, written by the director of the project, expounds the basic principles of the magnetic confinement and heating to high temperatures of an ionized gas in a machine of this type. It forms the introduction to a quite lengthy series of papers contained in *Physics of Fluids* **1,** nos. 4 and 5, 1958, in which a number of collaborators discuss a variety of theoretical and practical problems of the stellarator. This includes geometry of magnetic fields, problems of the stability of magnetically confined ionized gases, problems of heating by various methods, and parasitic phenomena and their prevention.

W. M. Elsasser, USA

2653. Coor, T., Cunningham, S. P., Ellis, R. A., Heald, M. A., and Kranz, A. Z., Experiments on the ohmic heating and confinement of plasma in a stellarator, *Phys. Fluids* **1,** 5, 411–420, Sept.–Oct. 1958.

The basic concepts of confinement of a plasma in a figure-eight stellarator are outlined and an experimental apparatus is described. Single particles can be confined by magnetic fields up to 30 Kilogauss for several milliseconds. The temperature reaches 10^6 degrees at the beginning of a run in helium, when ohmic heating is used. This condition does not last more than 100 microseconds before unstable processes occur. In particular the hydromagnetic kink instability predicted by Kruskal has been clearly observed. R. Betchov, USA

2654. Kruskal, M. D., Johnson, J. L., Gottlieb, M. B., and Goldman, L. M., Hydromagnetic instability in a stellarator, *Phys. Fluids* **1,** 5, 421–429, Sept.–Oct. 1958.

Authors investigate the stability of a column of plasma in the presence of a large magnetic field parallel to the column and its discharge current. For small perturbations, various helicoidal unstable modes are found. The external conductors have negligible effects on the stability of the column. In the case of the stellarator, a gradual twist of the cylindrical coordinates must be introduced. This leads to a critical discharge current for the appearance of helicoidal unstable motions. The experimental results are in good agreement with the theory for the first mode. The stability of higher modes is affected by the current distribution, and there is no evidence that they have serious effects.

R. Betchov, USA

2655. Bernstein, W., Chen, F. F., Heald, M. A., and Kranz, A. Z., "Runaway" electrons and cooperative phenomena in B-1 stellarator discharges, *Phys. Fluids* **1,** 5, 430–437, Sept.–Oct. 1958.

An experimental and detailed investigation of x-ray radiation from a B – 1 stellarator during pulsed discharge. The results cannot be explained by single-particle models or macroscopic plasma physics. The evidence suggests that "collective phenomena" do occur. The runaway electrons indicate the existence of instabilities at currents well below the Kruskal limiting current. Intense microwave radiation is also observed.

R. Betchov, USA

2656. Burnett, C. R., Grove, D. J., Palladino, R. W., Stix, T. H., and Wakefield, K. E., The divertor, a device for reducing the impurity level in a stellarator, *Phys. Fluids* **1,** 5, 438–445, Sept.–Oct. 1958.

The heavy ions released from the walls of the stellarator can be side tracked by a special magnetic device. This article contains a detailed discussion of the divertor, the various design problems, experimental procedures and some results. The impurity concentrations have been reduced by factors 2 to 3, perhaps even more in the core of the discharge. With the divertor the ion temperature has been increased from 40 eV to 60 eV for He, ionized once, and to 130 eV for O, ionized four times.

R. Betchov, USA

2657. Golitsyn, G. S., and Staniukovich, K. P., Some problems of magnetogasdynamics with account of finite conductivity, *Soviet Phys.-JETP* **6,** 6, 1090–1099, June 1958. (Translation of *Zh. Eksp. Teor. Fiz., Akad. Nauk SSSR* **33,** 1417–1427, Dec. 1957 by Amer. Inst. Phys., Inc., New York, N. Y.)

All problems discussed are strictly one-dimensional with all equations satisfied, i.e. transverse electric and magnetic fields are not freely assignable but satisfy Maxwell's equations [contrast Resler and Sears, *J. Aero. Sci.* **25,** p. 235, 1958]. For most of paper, ideal gas law is assumed. Authors first show that unsteady one-dimensional flow is governed by parabolically degenerate equations when conductivity is finite. An approximation of dubious value permits a return to hyperbolic equations. Authors then consider steady motions and point out criticality of *ordinary* sound speed. The augmented magnetohydrodynamic sound speed is significant only if the quantity (field/density) is constant. This is not the case with finite conductivity. Applicability of authors' work seems limited because all quantities must vary within lengths of order (*magnetic diffusivity/velocity*), i.e. the thickness of diffuse magnetic shocks. Authors go on to consider magnetic shock structure ignoring viscosity and thermal conductivity, with results similar to Burgers [AMR 11 (1958), Rev. 2664] and others. They also consider effect of finite conductivity on weak acoustic waves.

J. A. Shercliff, England

2658. Chuan, R. L., Plasma heating of hypersonic gas flow, AFOSR TN 57-762 (Univ. So. Calif. Engng. Center Rep. 56-202; ASTIA AD 136 751), 19 pp. + 2 figs., Dec. 1957.

For the production of condensation-free hypersonic flow in a wind tunnel it is proposed to add energy to the electrons in the air downstream of the throat by high frequency electrodeless discharge, and allow electron energy to go into random kinetic energy of the molecules in the decay process. Previous work in this respect has dealt only with the discharge process, measuring the energy that can be added to the plasma by various types of discharges. The present work examines the decay processes in an attempt to channel as much of the electron energy as possible into raising the temperature of the gas, by preventing losses by ambipolar loss mechanism. Inhibition of ambipolar diffusion by means of an axial, constant magnetic field is examined, as well as the attendant possibility of having such an inhibiting effect nullified by drain diffusion resulting from hydromagnetic instability. An experimental investigation is being initiated.

From author's summary

2659. Chopra, K. P., and Singer, S. F., Drag of a sphere moving in a conducting fluid in the presence of a magnetic field, Heat Transf. and Fluid Mech. Inst., Univ. Calif., Berkeley, Calif., June 1958, 166–175.

Three types of drag associated with magnetohydrodynamic flow are treated theoretically. First, induction drag is considered where the drag is basically due to joule dissipation of energy caused by induced currents either in the medium or the body. The magnetic field may originate within the sphere or in the external medium. The second drag is called coulomb drag and is associated with momentum transfer between a charged body and electrons and ions moving in the medium. The third type of drag is wave drag associated with energy transfer between highly charged particles moving in a plasma in the presence of an external magnetic field and plasma waves excited by the motion of the body. The plasma waves can propagate through the medium with a frequency below the critical and with phase velocity less than the material velocity of the body.

This paper is recommended to all interested in learning more of the fundamentals of plasma flow in magnetic fields. An understanding of vector notation is required however.

R. J. Mindak, USA

2660. Stix, T. H., and Palladino, R. W., Experiments on ion cyclotron resonance, *Phys. Fluids* **1,** 5, 446–451, Sept.–Oct. 1958.

The theory indicates the possibility of heating a plasma by feeding radio-frequency radiation (about 10 Mc). The article describes a small stellarator and the technique used to feed the energy, excite a helium plasma at the cyclotron frequency of the doubly charged ions, and measure the absorbed power. Experiments at the milliwatt level support the theory and indicate efficiency of at least 60%.

R. Betchov, USA

2661. Alpher, R. A., and White, D. R., Interferometric measurement of electron concentrations in plasmas, *Phys. Fluids* **1,** 5, 452–453 (Letters to the Editor), Sept.–Oct. 1958.

Aeroelasticity

(See also Rev. 2517)

2662. Woolston, D. S., and Sewall, J. L., Use of the kernel function in a three-dimensional flutter analysis with application to a flutter-tested delta-wing model, *NACA TN* 4395, 25 pp. + 7 tables + 7 figs., Sept. 1958.

Rayleigh-Ritz type of analysis, using natural vibration modes, is developed and applied numerically. Subsonic lifting surface theory is used. Method applied to a particular model, using the first three or four natural-vibration modes, yields flutter speed five percent less than experimental value. Effect of air density and Mach number variation is studied theoretically, as well as use of experimentally-determined natural-vibration modes.

G. Isakson, USA

2663. Morgan, H. G., Runyan, H. L., and Huckel, Vera, Theoretical considerations of flutter at high Mach numbers, *J. Aero. Sci.* **25,** 6, 371–381, June 1958.

Various unsteady aerodynamic theories for supersonic and hypersonic flow are reviewed and compared. Piston theory is shown to agree well with Van Dyke's more exact second-order theory for M 2 to 3, and extension to very high M is discussed. A nonlinear pressure method is proposed for lower M and moderate frequency; since the application is not mathematically straightforward, the accuracy must remain questionable and the usefulness doubtful. A limited parametric flutter study according to piston theory is given, indicating the generally destabilizing effects of thickness at bending-torsion frequency ratios less than about one.

H. M. Voss, USA

2664. Lambourne, N. C., Effect of boundary layer thickness on flutter of control surfaces—a brief survey of relevant reports, *AGARD Rep.* 183, 2 pp., Mar.–Apr. 1958.

Reports which contain information relevant to an assessment of the influence of the boundary layer on the flutter of control surfaces are listed. All the reports except one are concerned with the aerodynamic hinge-moments or pressure distributions for oscillating control surfaces and do not deal with flutter directly. The exception contains measurements of flutter characteristics in addition to hinge-moments. For all the measurements it would appear likely that the boundary layer remained attached to the surface of the airfoil up to the trailing-edge; thus no separation effects are included. Except for one report (Ref. 10), conditions are restricted to incompressible flow.

From author's summary

2665. Gorelov, D. N., Wing flutter in a flow of gas (in Russian), *Vestn. Leningr. In-ta* no. 1, 192–196, 212, 1957; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10131.

The problem is investigated of the flutter of a wing of infinite span in a plane flow. The method utilized, with small variations,

was developed in an article by N. Rott. It should be noted that at the given value of shear phase between the torsion and deflection of the wing the completion of the inequality (29) of the study referred to appears to be a condition of the absence of torsion-deflection flutter. The problem is also examined of the possibility of the appearance of pure torsional flutter of a wing; the conditions are indicated under which this type of flutter is possible.

Zh. K. Makhortykh

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Aeronautics

(See also Rev. 2519)

2666. Wolf, H., and Pines, S., A rational determination of loads and exit velocities of cartridge ejected stores, *J. Aero/Space Sci.* **25,** 7, 425–428, July 1958.

Paper views store ejection mechanism as a gun which is supported by a spring; the spring represents the elastic support (such as a flexible wing) of the ejection mechanism. The gun contains a chamber in which a propellant burns producing gas which propels a piston (the store) from the gun. The mechanism behavior is described by a system of differential equations arrived at from the ideal gas law, thermodynamics laws, an empirical expression for burning rate as a function of pressure and Newton's law applied to gun and to piston. These equations were integrated on an analog computer for a number of cases. The pressure-time curves calculated on the computer agreed well with experimental data. The calculated peak force experienced by the spring (and hence by the structure which supports the spring) is plotted as a function of store exit velocity for various chamber initial volumes, various piston (store) areas, and for various stiffnesses of spring. Increasing the flexibility of the spring is seen to reduce the peak force on the supporting structure and to reduce the store velocity.

Reviewer notes that since the store velocities are low (e.g., 20 fps) relative to the sound speed in the propellant gas, the pressure and density may be assumed to be the same throughout the entire gas at any given time. This simplification cannot be made in the analysis of conventional guns. A. E. Seigel, USA

2667. Hamilton, W. T., Jet transport flap considerations, *Aero. Engng. Rev.* **16,** 12, 52–55, Dec. 1957.

Author analyzes take-off ground run and initial climb for a four-engined jet aircraft (such as Boeing 707) with four flap systems: mechanical, boundary-layer control, jet-augmented external flow, and pure jet. For high weight (long take-off runs) there is little advantage in the more exotic systems; these may offer some advantages (by delaying flow separation) for shorter take-off runs where larger thrust-weight ratios are required.

A. W. Babister, Scotland

2668. Morduchow, M., and Muzyka, A., Analysis of harmonic forces produced at hub by imbalances in helicopter rotor blades, *NACA TN* 4226, 36 pp. + 1 fig., Apr. 1958.

Expressions are derived for the forces, both in and normal to the plane of rotation, produced at the hub of an n-bladed unbalanced helicopter rotor. Two types of imbalances which are unavoidable in practice are treated, viz. imbalance due to small differences in construction of the rotor blades, and imbalance due to slightly unequal angular spacings between the blades. These two types of imbalances, which are shown to have equivalent effects, cause additional forces in all of the harmonics, while for a rotor of n perfectly balanced blades the only forces transmitted to the hub are the harmonics which are multiples of n. Especially the magnitude of the additional lower harmonics may be appreciable, as is shown by numerical examples.

J. H. Greidanus, Holland

Astronautics

(See also Revs. 2514, 2636, 2646, 2649, 2681)

2669. Lawden, D. F., The employment of aerodynamic forces to obtain maximum range of a rocket missile, *Aero. Quart.* **9,** 2, 97–109, May 1958.

The programming of the thrust direction for a rocket-powered missile which flies in a resisting medium over a flat earth is investigated. It is assumed that the aerodynamic forces are small with respect to the missile weight, so that the aerodynamic effects are regarded as perturbations superimposed on the known optimum trajectory in the absence of aerodynamic forces. An application of the theory is carried out to the case of a V-2 rocket flying along either a lifting path or a non-lifting path.

A. Miele, USA

2670. Liu, V. C., Theory of flight of the sounding rocket, *J. Appl. Mech. (Trans. ASME Ser. E)* **26,** 1, 127–129, Mar. 1959.

Solutions of the equations of motion of vertically ascending rockets (both in power flight and in free flight) are given in closed form. Atmospheric density is assumed to vary exponentially with altitude, and the variation of the drag coefficient of the rocket with Mach number is assumed to follow a definite pattern. (The validity of the latter assumption is established by its close agreement with measured results.) These solutions, given in terms of special transcendental functions, can be used for the rapid estimation of sounding-rocket performance, eliminating the often-used laborious process of stepwise integration. The general rocket-performance parameters prescribed in the analysis also can be used to advantage in comparing and selecting multistage sounding rockets. From author's summary

2671. Powell, A., On the effect of missile motion on rocket noise, *J. Acoust. Soc. Amer.* **30,** 11, p. 1048 (Letters to the Editor), Nov. 1958.

On the assumption that turbulent mixing accounts for the major part of rocket noise, it is tentatively suggested that the rocket noise intensity at a given point on a missile varies as

$$\left[\frac{M_i - M_m}{M_i}\right]^3 (1 - M_m)^2,$$

where M_i is the highly supersonic Mach number of the jet efflux relative to the exit, and M_m is the subsonic Mach number of the missile, both referred to the speed of sound in the external air. The frequency characteristics are little affected.

From author's summary

2672. Bossart, K. J., Departure and return in interplanetary flight, *Aero/Space Engng.* **17,** 10, 44–52, Oct. 1958.

Paper deals with some of the three-dimensional aspects of orbits in close vicinity to the planet—i.e., orbits of arrival and departure—studied from the standpoint of flight economy. It is assumed that we are dealing with high thrust accelerations such as would be obtained from chemical propulsion. One special case of arrival, the return to earth, is briefly considered.

From author's summary

Ballistics, Explosions

(See also Rev. 2483)

2673. Duff, R. E., Knight, H. T., and Rink, J. P., Precision flash X-ray determination of density ratio in gaseous detonations *Phys. Fluids* **1,** 5, 393–398, Sept.–Oct. 1958.

Authors' objective is to determine precisely the density ratio across detonation waves using a flash x-ray densitometer [cf. H.

T. Knight and D. Venable, *Rev. Sci. Instrum.* **29,** p. 92, 1958]. Measurements are reported for two mixtures of acetylene, oxygen, and krypton, one of hydrogen, oxygen, and krypton, and two of cyanogen, oxygen, and krypton. Enough repetitions were made to establish an accuracy of 1%. Detonation tube diameters and initial pressures were varied to permit extrapolation of the density ratios to infinite diameters and pressures. The values thus obtained are not in agreement with those calculated from detonation theory. For example, the mixture 0.3 C_2H_2 + 0.3 O_2 + 0.4 Kr gave an observed density ratio of 1.70 at infinite diameter while the tangent point on the equilibrium Hugoniot from the initial state corresponds to 1.79. Reviewer believes that this paper indicates an avenue of research that will lead to an improved understanding of the detonation process. J. W. Givens, USA

2674. Martin, F. J., Transition from slow burning to detonation in gaseous explosives, *Phys. Fluids* **1,** 5, 399–407, Sept.–Oct. 1958.

The formation of detonation waves in an equimolar mixture of acetylene and oxygen at a pressure of 50 mm of mercury was studied in a tube 3.4 m long and 5 cm in diameter. An optical system was provided that permitted taking direct rate, schlieren, and flame structure pictures. The results show that within the first 30 cm of travel the flame accelerated to a velocity of 800 m/sec^{-1}. For the next 50 cm the velocity remains nearly constant and a shock is generated ahead of the flame and moves at a slightly higher velocity. The flame then develops an irregular configuration and the transition to detonation occurs when the Reynolds number of the mass flow between the flame and the shock is about 10^7. The onset of detonation appears to be related to the development of turbulence in the boundary-layer flow ahead of the flame. Reviewer is of the opinion that a practical method has been developed for studying the initiation of detonation. The extension of the work to other components and conditions seems highly promising. J. W. Givens, USA

Acoustics

(See also Revs. 2239, 2525, 2540, 2597, 2657, 2671, 2720)

2675. Freeman, I. M., Acoustic behavior of a rubber string, *Amer. J. Phys.* **26,** 6, 369–371, Sept. 1958.

The fundamental transverse vibration frequency of a rubber string remains almost constant when the string is stretched to greater lengths, in sharp contrast with the behavior of a nearly inextensible string. Using the known elastic properties of rubber, the results of the analysis are found to agree quantitatively with experiment. From author's summary

2676. Murphy, S. R., Garrison, G. R., and Potter, D. S., Sound absorption at 50 to 500 kc from transmission measurements in the sea, *J. Acoust. Soc. Amer.* **30,** 9, 871–875, Sept. 1958.

The absorption coefficient of sound in sea water has been obtained by a series of direct transmission measurements at several moderately high frequencies in a sheltered deep water bay in Puget Sound. Advantage was taken of the isothermal and isosaline properties existing during certain seasons of the year in this location. The fluctuations normally encountered in such a measurement were minimized by the utilization of fixed buoys, a radio link for range determination by acoustic travel time, and a method of space averaging. Values obtained, in decibels per kiloyard at a temperature of 10 C and a salinity of 30 parts per thousand, are: 14.4 ± 0.3 at 60 kc, 35.7 ± 0.7 at 142 kc, 57 ± 3 at 272 kc, and 101 ±3 at 467 kc. Although the frequency dependence of the absorption coefficient given by these measurements follows the normal relaxation law, the magnitudes are lower than those given by Del Grosso by 4 to 10 db/kyd. From authors' summary

2677. Kontorovich, V. M., Reflection and refraction of sound by a shock wave, *Soviet Phys.-JETP* **6,** 6, 1180–1181 (Letters to the Editor), June 1958. (Translation of *Zh. Eksp. Teor. Fiz., Akad. Nauk SSSR* **33,** 1527–1528, Dec. 1957 by Amer. Inst. Phys., New York, N. Y.)

2678. Morse, R. W., Properties of matter—solids (from Symposium on unsolved problems in acoustics), *J. Acoust. Soc. Amer.* **30,** 5, 380–382, May 1958.

2679. Litovitz, T., Properties of matter—the liquid state (from Symposium on unsolved problems in acoustics), *J. Acoust. Soc. Amer.* **30,** 5, 383–384, May 1958.

2680. Watters, B. G., Design of wedges for anechoic chambers, *Noise Control* **4,** 6, 32–37, Nov. 1958.

Sound-absorptive wedges cover walls of rooms used for sound measurements. This article explains how they work and principal features of design. Best results require cut-and-try adjustments; tests for a special chamber are described.

From author's summary

2681. Veneklasen, P. S., Missile noise as a factor in reliability, *Aero/Space Engng.* **17,** 9, 44–48, Sept. 1958.

2682. Wiener, F. M., Goff, K. W., and Keast, D. N., Instrumentation for study of propagation of sound over ground, *J. Acoust. Soc. Amer.* **30,** 9, 860–876, Sept. 1958.

An instrumentation system has been developed to allow continuous determination of the relevant micrometeorological parameters of the atmosphere near the ground in order to relate them to the measured attenuation of an acoustic signal propagated along the ground. Arrays of precision cup anemometers and shielded thermocouples mounted on a 30-ft tower were used to obtain the mean wind and temperature gradients above the ground. To obtain a measure of the atmospheric turbulence, a high-speed wind vane and a bead thermistor were used. The electrical signals obtained from scanning these transducer arrays were fed into a mobile central recording and control facility. Simultaneously, the information provided by the acoustic signal was recorded there by scanning the output of several microphones placed along two test courses each approximately one mile long. The mobile laboratory also contained the necessary equipment for energizing two loudspeakers, one for each test course. This paper discusses the micrometeorological instrumentation in some detail, together with the calibration techniques used. Typical mean wind and temperature profiles as well as turbulence spectra are presented. The relation of the micrometeorological data to the propagation of sound along the ground is discussed elsewhere. From authors' summary

2683. Fehr, R. O., Noise, shock and vibration (from Symposium on unsolved problems in acoustics), *J. Acoust. Soc. Amer.* **30,** 5, 385–386, May 1958.

2684. Numachi, F., Transitional phenomena in ultrasonic shock waves emitted by cavitation on hydrofoils, ASME Ann. Meet., New York, N. Y., Nov.–Dec. 1958. Pap. 58-A-117, 10 pp.

In some cases during the experiments described in past reports which dealt with cavitation-induced ultrasonic shock waves, extremely anomalous values were obtained in the imparted pressure of the shock waves. Present paper deals with an investigation into the nature of these shock-wave anomalies, and it is demonstrated that these anomalies can be caused not only in closed-circuit cavitation tunnels but can be produced in any flow subjected to preliminary cavitation at a point upstream of the point of principal cavitation. The nature of the anomalies occurring in the shock-wave spectrum was studied, and its relation to cavitation-bubble size was made clear. From author's summary

Micromeritics

(See also Revs. 2617, 2619)

2685. Neronov, N. P., Zakharevich, A. F., and Zhuravlev, P. A., Theory of vibration machines (in Russian), *Zap. Leningr. Gorn. In-ta* **33**, 3, 3–36, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 9961.

A study is made of the movements of a model vibrator machine, intended for the transport and sorting of granulated materials. The machine consists of two parallel frames, the lower of which rests on four buffers, while the upper is connected to it by means of flat springs; the two frames together form an elastic parallelogram. To the lower frame is attached a motor with an eccentric load, acting as a vibrodrive-energizer for the vibrating of the system. The nature of the pre-resonance as well as of the after-resonance effect is investigated. The problem merges with the integration of a system of differential linear equations with varying coefficients which is derived by the method of the small parameter. The results obtained permit the determination of the frequencies of the free vibrations and the conditions governing the resonance of the system. The combination of the data enables one to calculate the strength of the vibrating parts of the machines. V. N. Geminov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2686. Chernov, A. P., Coefficient of resistance of finely divided solid particles (in Russian), *Izv. Akad. Nauk KazSSR, Ser. Energ.* no. 9, 160–166, 1955; Ref. Zh. Mekh. no. 9, 1957, Rev. 10634.

Author examines the divergence in the results of the determination of the value for the coefficients of resistance of finely divided particles in an air flow from his earlier work, obtained for the coefficient of resistance of particles of incorrect form of a value higher than that for the coefficient of resistance of a sphere of equivalent diameter, and in the work of G. N. Khudyakov, who obtained a value for this magnitude less than that for a sphere of equivalent diameter. In the author's view, Khudyakov's attempt to explain this result by rotation of the particles does not appear to be satisfactory, as not all the particles are rotating in the flow and as at the existing velocities of rotation the influence of rotation on the resistance coefficient is of little significance. Author explains Khudyakov's results by implying inaccuracy in the determination of the particle velocities and by criticizing the graphical differentiation of the distribution of the particle velocity along the length of the tube, used by Khudyakov when determining the coefficients of resistance. Working through the experimental data obtained by Khudyakov again, the author, utilizing his fixed points draws new curves and, differentiating, obtains other values for the coefficients of resistance, larger than the corresponding value for a sphere of equivalent diameter.

G. I. Barenblatt

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2687. Mel'ttser, L. V., Application of radioactive methods for the automatic control of consumption and extent of dustiness of gaseous media (in Russian), Sb. Rabot po Avtomatike i Telemekhan., Moscow, Akad. Nauk SSSR, 1956, 211–227; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10732.

The possibility is investigated of obtaining an ionic cloudlet, using a modulated radioactive irradiation device; a preliminary evaluation is given of the measurement appliances for the automatic control of the gas consumption (using the impulse and phase method) and the extent of its dustiness by the method of migration of the ionic cloudlet. The modulated radioactive irradiation, penetrating into the pipe conduit, forms packets of ions which are carried with the flow to the collector placed lower down in the flow and sets up in it a chain of currents. The measurement appliances are tested for each method by one of the possible variants of the main scheme. The processes connected with the formation and migration of the ionic bundles and those connected with stress formation at the amplifier inlet are described. An analysis of the work done by appliances for the automatic control of gas consumption shows that, when using an α-source, with an activity of m curie for a solid angle of 0.15 and active time of exposure to radiation of $100\,\mu$ sec (the diameter of the pipe conduit is 8–10 cm), the number of pairs of ions in the bundle for air is about 8×10^3. The full number of ions at the point where the collector is situated, taking into account the recombination of ions during the carry-over of 50 and $5\,\mu$ secs is, respectively, 10^3 and 2.5×10^5. It is established that with the same values for the tube conduit's diameter and for the magnitude of the solid angle the activity of the source of the β-irradiation should be selected at, say, 2.5 times more than the activity of the source of the α-irradiation. The question is also examined of the application of radioactive isotopes for the determination of the dustiness of the gas flow in the pipe conduit simultaneously with the measurement of the consumption when using as an ionizing medium an electric discharge. The discharger and the α-isotope are disposed in the pipe conduit. The feed pressure of the discharger is so arranged that the discharge only occurs when α-particles fall into the space between the electrodes. At a determined distance between the discharger and the α-source the appearance of liquid or hard substances requires the reduction of the length of run of the α-particles and, in consequence, of the number of discharges in a unit of time. In the case of utilizing α-particles, a quantitative evaluation is given of the processes which are under observation when measuring the extent of dustiness. It is noted that β- or α-irradiations cannot be used for this purpose because of their insignificant ionizing capacity. V. S. Merkulov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2688. Baldina, O. M., Determination of tangential velocities and level profile of water in detachable cyclones (in Russian), *Energomashinostroenie* no. 5, 7–11, May 1956.

2689. Egiazarov, I. V., A general equation of the limit transporting capacity of cohesionless sediment in open channels (in Russian), *Dokladi Akad. Nauk SSSR* (N.S.) **107**, 4, 525–528, Apr. 1956.

2690. Kharlamov, P. V., Integrable cases in problems on the motion of heavy solid bodies in fluids (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)*, **107**, 3, 381–383, Mar. 1956.

2691. Zagar, L., Characteristics of discrete disperse systems (in German), *Kolloid Z.* **130**, 1, 1–10, Jan. 1953.

The shape and position of the grain-size distribution curve of a discrete disperse system can be defined by two statistical parameters, the geometric-median grain size and the geometric scatter. With these there are defined also the significant physical characteristics of the system: the specific surface, the number of particles in a gram of dispersoid, the size of the particle having the median surface, and the size of particle having the median volume. This functional relationship can be fully utilized only if the characteristic constants which are valid for the grain shape for the specific powder type are first determined. These are: the surface factor, the volume factor, and the shape factor. According to the theoretical treatment described in detail in the paper, granulometric analyses have been carried out on 23 metal powders. The number of particles in one gram is determined by the counting chamber method, and the specific volume by air-permeability measurement. From these the shape factors are calculated, using carbonyl powder as testing standard. Paper gives a thorough theoreti-

cal background, and while it deals primarily with solid particles, its method and findings are applicable also to droplet populations.

K. J. DeJuhasz, Germany

2692. Dityakin, Iu. F., and Iagodkin, V. I., Influence of periodic vibrations of velocity and density on the disintegration of liquid jets (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 4, 115–120, Apr. 1957.

Writers consider theoretically the influence of the oscillations of the velocity in a liquid jet and the density of the medium, surrounding a cylindrical liquid jet, on the disintegration of the jet. They use the method of small perturbations beginning with the velocity potential equation. The following conclusions are derived: (a) During the oscillations of the velocity of a liquid jet the character and the length of the waves of the unstable perturbations are subject to change and there appears a great number of separate unstable oscillations; (b) the oscillations of the velocity of the liquid jet and the density of the surrounding medium cause a decrease in the dimensions of the drops appearing during the process of disintegration; (c) the theoretical results are in agreement with experimental tests.

M. Z. v.Krzywoblocki, USA

2693. Degtev, O. N., Atomization of viscous liquids (in Russian), *Tr. Ural'skogo Politekhn. In-ta* no. 61, 95–105, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10263.

Existing presentations of the process of atomization of liquids are discussed. An analysis is carried out of the formulas proposed by different authors for the calculation of the diameter of the drops of liquid in the process of atomizing. On the basis of known facts regarding the atomizing process a deduction is made on the existence of two variants of this process: (1) the break-down of the stream under the influence of static instability; (2) the secondary fractionation of the drops when the determining factor appeared to be the effect of aerodynamical forces. Author regards as inconsistent the attempts to obtain a relation between the final diameter of the droplets and the original parameters by the aid of the theory of instability of the jet and the theory based on the reaction of turbulence on the break-down of the jet. Criteria are deduced, characterizing the atomizing process, by investigations of the forces acting on the droplets during secondary fractionation (aerodynamic forces, forces of internal friction and forces of surface tension). The criterial equation for the atomizing process of a viscous liquid has the form

$$D = A\Pi^n,\ D = \frac{\rho u^2 d}{\sigma},\ \Pi = \frac{\mu w}{\sigma}$$

where D is the fractionation criterion, ρ the density of the surrounding medium, μ the viscosity of the liquid being atomized, σ the surface tension coefficient, w the relative velocity of the droplet, d the diameter of the droplet. Experiments were carried out on the atomizing of slag obtained from the cupola-furnace smelting (of iron ore) (composition: silicon oxide ~ 43%, calcium oxide 24% aluminum oxide ~ 17%, the remainder—oxides of iron and magnesium). For the atomizing a pneumatic sprayer was used and a device with rotating vanes. The slag particles after atomizing were air cooled and then sieved in order to obtain the curves for classification by particle size. The experiments showed that when atomizing slag with the aid of rotating vanes for a range of criteria $\Pi < 40 < 1700$ the coefficients of the criterial equation have the values of $A = 1.72$, $n = 0.425$.

Yu. F. Dityakin

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

2694. Amelin, A. G., and Beliakov, M. I., On the deposition of drops from a flow (in Russian), *Doklady Akad Nauk SSSR (N.S.)* **108,** 1, 31–33, May 1956.

Porous Media

(See also Revs. 2348, 2441, 2457)

2695. Carrier, G. F., The mixing of ground water and sea water in permeable subsoils, *J. Fluid Mech.* **4,** 5, 479–488, Sept. 1958.

Author investigates the transition zone between the fresh water zone and the salt water zone found in permeable islands. This transition zone results from mixing due to periodic tidal pressure. The difference formulation of C. K. Wentworth is described and author demonstrates the equivalence of a continuum model described by a differential equation. The one-dimensional case with a spacially varying velocity field is considered and with certain simplifying assumptions, justified by the physical conditions, equations are derived. These demonstrate that the mixing resulting from a fluid velocity distribution of the form $Ey + v \cos \omega t$ is essentially equivalent to that in a fluid of diffusivity $2v\Delta/\pi$ which moves with the velocity Ey relative to a coordinate system moving at a speed $v \cos \omega t$, where Δ is the assumed basic cell size. This simplification is then used in the derivation of a differential equation for a two-dimensional model. Author also demonstrates that, for typical conditions, the convection mechanism is dominant and that molecular diffusion can be neglected.

G. C. Wallick, USA

2696. Nisle, R. G., The effect of partial penetration of pressure build-up in oil wells, *J. Petr. Technol.* **10,** 5, 85–90, May 1958.

Author considers the problem of pressure build-up in shut-in oil wells when the well only partially penetrates the producing formation. An integral expression is derived for the pressure change as a function of time due to a well partially penetrating a uniform slab of finite thickness but of infinite lateral extent. Only the single phase, slightly compressible fluid case is treated. Synthetic pressure build-up curves are presented, based upon the numerical evaluation of the derived expression. It is observed that, for times immediately after the well is shut-in, the slope of the build-up curve for a partially penetrating well is approximately equal to that for 100% penetration. For later times the slope is roughly equal to the product of the 100% slope and the ratio of well penetration to formation thickness. Author points out that in the ideal case it should be possible to determine the degree of penetration from the initial and final slopes of the build-up curve.

G. C. Wallick, USA

2697. Aver'yanov, S. F., and Sin-e, Ts., On the design of drainage in the presence of inflow (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 3, 115–124, Mar. 1957.

Steady drainage conditions are assumed in this problem involving parallel equidistant straight drains placed in the uniform water-bearing soil underlain by a horizontal impervious layer. A constant uniform downward inflow maintains the steady flow condition. The solution is approximate in view of some simplifying assumptions with relation to the boundary. Special cases, one involving the location of the impervious layer at infinite depth, and the other at the level of the drains are also considered, and some numerical solutions are given.

A. P. Hrennikoff, Canada

2698. Tsitskishvili, A. R., Seepage from a channel of trapezoidal cross section (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 3, 125–133, Mar. 1957.

Paper presents the mathematical solution of the problem of seepage through the sides and the bottom of a channel of symmetrical trapezoidal cross section. The uniformly pervious soil material surrounding the channel is either underlain at some depth by an impervious material, or is extended down indefinitely, in which case the ground water level may be present at finite or infinite depth. Special cases of triangular and rectangular cross sections are also considered, and some graphs illustrating the solution are given.

A. P. Hrennikoff, Canada

2699. Lubyako, G. N., Basic equations of motion of soil waters towards the drains in heterogeneous soils (in Russian), *Tr. Aralo-Kaspiisk. Kompleksnoi Ekspeditsii Akad. Nauk SSSR* no. 7, 197–221, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10697.

A series of cases was investigated in considerable detail to cover pressure and non-pressure flows for a particular scheme of filtrational heterogenity of soils, where the draining stratum was situated below a river, feeding it through an interlayer of feeble permeability. In addition, other cases were examined where the stratum was fed from below from underlying levels, also through an interlayer of small permeability. When making a plan for the flow, N. K. Girinskii's premise is taken, in agreement with which the Dupuis premise is accepted in the basic drainage stratum, while in the feebly permeable interlayers the lines of current are assumed to be vertical. V. M. Shestakov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2700. Kostinenko, G. I., Lowering of the humidity contents in soils (in Russian), Problems in the study of underground waters and engineering-geological processes, Moscow, Akad. Nauk SSSR, 1955, 41–59; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10687.

Experiments were carried out in sectional tubes to observe the movement of capillary water in sands from the coarse particle fraction to the fine, and also when in contact with different soils (varying from loamy to sandy). The tubes consisted of three portions connected at right angles: vertical, with the open end let into the water, horizontal and the second vertical portion, disposed above the container, which collected the thrown-off water. The experiments showed that the water travels from the coarse-granular fraction to the fine granular. This travel of capillary water takes place intensively from sand to loam. Locomotive and boiler cinders remove the water from loam saturated with water. The results of special experiments are given; these were carried out in special boxes to investigate the lowering of the humidity in sandy soils with downward water-drainage. The experiments showed that fine granular permeable materials draw off the water well from the coarser granular sands; in the process the lowering of the capillary water level in the sands only takes place at a thickness of the layer of material being drained equal to (or greater than) the height of the capillary lift of water in the actual material being drained. In the case of soils with large capillary lift (for instance, in the case of light loams swelling slightly, it is recommended, for the purpose of lowering the capillary water content, to use turf and cinder dust, which by capillary action lift the water to the earth's surface, where it evaporates. A. R. Shkirich

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2701. Pirverdyan, A. M., Inflow of liquid to a rectilinear chain of wells (in Russian), *Tr. Azerb. N.-i. In-ta po Dobycbenefti* no. 3, 94–96, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10667.

A simple deduction of the known formula by I. A. Charnyi is put forward for the determination of the inflow of petroleum to an infinite chain of wells, all in identical conditions, and arranged in a semi-infinite stratum with a rectilinear contour of feed.

V. A. Karpychev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2702. Khein, A. L., Approximate theory on the steady inflow of liquid and gas to incomplete wells with a meridian-symmetrical construction on the face (in Russian), *Tr. Vses. Neftegaz. N.-i. In-ta* no. 8, 142–178, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10663.

2703. Guseln-zade, M. A., Generalization of the problem of computing the permeability of the covering and the under-layer of a stratum when a liquid in it is in motion (in Russian), *Tr. Mosk. Neft. In-ta* no. 16, 70–81, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10660.

An approximate method is examined of the solution of the problems of the movement of a liquid in two strata separated by a weakly permeable interlayer. The problem is solved with the following asumptions:

(1) The strata and the interlayer are incompressible and uniform as regards capacity and permeability, while the coefficients of permeability and capacity for each stratum have different values.

(2) The upper stratum has an absolutely impermeable covering, while the lower, an absolutely impermeable bottom.

(3) The liquid in motion is incompressible, the principle of filtration is linear, while the motion is steady and plane; consequently the pressure in each of the strata satisfies Laplace's equation.

(4) On the line of division the liquid in the separating interlayer moves perpendicularly to its boundaries.

The last assumption increases in accuracy as the permeability coefficient of the separating interlayer becomes less in comparison with the permeability coefficients of the producing strata. The solution is obtained in the form of a series from hyperbolic and trigonometrical functions. The solution found permits, in particular, the determination of the inflow or leakage through the feebly permeable interlayer from one of the productive strata into the other. The same method is employed for the investigation of an axially symmetrical flow in two uniform strata, separated by a feebly permeable interlayer. P. F. Fil'chakov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2704. Guseinov, G. P., Approximate method of solution of non-stationary problems in the theory of filtration (in Russian), *Tr. Azerb. N.-i. In-ta po Dobyche Nefti* no. 3, 114–138, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10672.

An approximate method is proposed for the solution of the equation of a one-dimensional motion of an elastic liquid (the equation of heat conductivity) and a gas (Boussinesq equation) in a porous medium. The method is based on the averaging of the value $\partial p/\partial t$ in the equations

$$\frac{\partial p}{\partial t} = \frac{1}{l}\int_0^l \frac{\partial p}{\partial t}\,dx = F(t)$$

For the filtration of an elastic liquid the problems are investigated of the inflow to the rectilinear and circular galleries at a pressure or yield assigned to the galleries in terms of functions with time. For the filtration of the gas an investigation is made of the inflow to a rectilinear gallery at a given constant yield or pressure. In all the problems, cases were examined where impermeable boundaries in the layer were present. Comparisons were made with the exact solutions. The author remains ignorant of the fact that the problem of the filtration of an elastic liquid in a rectilinear gallery and the problem analogous to the filtration of gas in a rectilinear gallery (in the case where the pressures have been assigned) were solved in exactly the same manner by Yu. D. Sokolov. A. M. Suponitskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2705. Zhantykov, O. A., A problem in filtration (in Russian), *Izv. Akad. Nauk KazSSR, Ser. Mat. i. Mekh.* no. 4, 70–79, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8101.

An investigation is made of a case of plane radial irregular filtration of a homogeneous elastic liquid in an elastic layer extending to infinity. The inflow is examined to a well with radius R_c, inside radius zone R_K: The porosity of the layer is taken to be equal to m, permeability K, coefficient of piezo conductivity a^2:

the volumetric yield of the well is taken to be a constant. Pressure $p(r,t)$ for any point in the layer is determined. The problem merges with the one for finding the solution of the differential equation

$$\frac{\partial^2 p}{\partial r^2} + \frac{1}{r}\frac{\partial p}{\partial r} = \frac{1}{a^2}\frac{\partial p}{\partial t} \qquad [1]$$

satisfying certain initial and boundary conditions; one of the conditions is: $p(r,0) = \varphi(r)$. Making use of Laplace's transformation

$$\bar{p}(r,s) = \int_0^\infty p(r,t)e^{-st}\,dt \qquad [2]$$

author changes equation [1] to the form

$$\frac{d^2\bar{p}}{dr^2} + \frac{1}{r}\frac{d\bar{p}}{dr} - \frac{s}{a^2}\bar{p} = -\frac{s\varphi(r)}{a^2} \qquad [3]$$

This result is incorrect, because in the right hand side of the equation the multiple s appears to be superfluous. This error reoccurs in further computations of the author.

V. A. Karpychev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2706. Rabinovich, M. I., and Chavradov, A. S., Determination of the hydraulic resistance of a layer of finely grained material (in Russian), *Sb. Trudï In-ta Teploenerg., Akad. Nauk USSR* no. 13, 135–143, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8115.

An experimental investigation of the hydraulic resistance of a layer consisting of particles of a lignite semi-coke. The experiments were carried out with charges consisting of fractions of particle size 1.68 – 0.84 mm, 0.84 – 0.59 mm, 0.210 – 0.149 mm, and 0.149 – 0.105 mm. The results of the tests are presented in the form of graphical relations: pressure drop due to flow velocity; resistance coefficient of the channel, the equivalent to the charge layer of given porosity, from Reynolds number; and the resistance coefficient of the layer from the corresponding (relevant) Reynolds number. Two systems of motion were under observation, corresponding to the stable undisturbed layer and the unstable disturbed or "boiling" layer. As regards the former, observations were made of the motion, corresponding actually to the linear principle of the dependence of resistance on velocity. After transition from the critical velocity the motion takes on an unstable, fluctuating character and the charge resistance drops sharply. In the first approximation the principle of resistance of the boiling layer is expressed by the formula $\lambda = \frac{\Delta}{R^n}$ where Reynolds number is assumed to correspond to the stable undisturbed layer, $n \approx 2$. The tests showed that the disruption of the layer for even the largest coarse fraction 0.84 – 1.68 mm sets in at a critical velocity of the order of 0.38 – 0.40 m/sec, which corresponds to a filtration rate of 0.20 – 0.25 m/sec.

E. M. Minskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2707. Salekhov, G. S., Sidorenko, V. S., and Chugunov, V. D., Problem on the control by motion of the petroleum bearing contour (in Russian), *Neft, Kh-vo* no. 8, 30–35, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8100.

A solution is presented for particular problems of control by motion of a petroleum-bearing contour when the stratum is under water pressure, and also of check calculations of some of the results on the electro-integrator. A round layer is investigated with constant thickness b, permeability and effective porosity m. The viscosity of the petroleum and water is taken to be equal; the motion follows the linear principle of filtration. The wells are replaced by point outlets and springs. The distribution and yield of the wells are looked for in such a manner that the petroleum-bearing contour at the initial position $\Gamma_{(0)}$ (the surroundings of radius r_0) in the best possible way (in the sense of the smallest mean quadratic declination) is drawn toward the contour Γ_1 for a time T according to the principle $r^2 = r_0^2 - (t/T)(r_0^2 - r_1^2)$.

The following problems were solved on the integrator: (1) The stratum is worked by two batteries, the radii of which are Q_1 and Q_2; the orifices in the batteries are located at equal distances from each other. The yields and the relative distribution of the battery orifices are found. (2) The stratum is opened by two batteries, the radii of which are Q_1 and Q_2; the number of orifices in the batteries $2n$ and $3n$ is suitable, the disposition of the orifices is known. Assigning a yield to one of the orifices, the yield of the rest is determined. (3) The stratum is opened by two batteries, with n orifices in each; when one of the batteries is working, the other is forcing. In all the examples it is assumed that the boundary water stretches to infinity. The integrator check showed a satisfactory agreement of the desired and actual petroleum-bearing contours.

V. A. Karpychev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2708. Krinari, A. I., Methods of determination of the gas permeability of rocks (in Russian), *Izv. Kazansk. Fil. Akad. Nauk SSSR, Ser. Geol. Nauk* no. 3, 131–137, 1955; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8111.

The gas permeability coefficient is determined, as usual, from the d'Arcy principle for a single dimension flow of an ideal gas. To accelerate the calculations three tables are included in the paper. However, these tables are not of universal application. Coefficient K_T introduced by the author depends on the viscosity of the gas; in the test, however, the gas viscosity is not indicated though the tabulated data for the coefficient is calculated in accordance with this viscosity. Besides, the gas viscosity depends on pressure as well as the temperature. The principle governing the compilation of Table 2, and the selection of the dimensions given in it, is not understandable. Author deals with the concept of the coefficients of permeability and filtration as one, though it is usual to determine them separately. There are a number of misprints in the article.

G. L. Govorova

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2709. Istomina, V. S., The filtration stability (strength) of cohesive soils (in Russian), Vopr. Fil'strats. Raschetov Gidrotekhn Sooruzhenii, Moscow, Gos. Izd. vo Lit. po Str-vu i Arkhitekt. no. 2, 140–189, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8113.

The strength of clayey soils is investigated when subjected to the action of a filtration flow of liquid, when used in earthen dams, filters, drains and in the foundations of hydrotechnical installations. The principal factor influencing the filtration strength of a cohesive soil is assumed to be the interlinkage. As instances of filtration deformation in cohesive soils investigations are made of suffusion, overflow, contact overflow, peeling and contact erosion. A description is given of the experimental investigations on these forms of deformation. The presence of molecular interlinkage between the particles and atoms leads to the absence in cohesive soils of suffusion phenomena even when the pressure gradients are very large, exceeding 10. Coverflow is observed with disruptive gradients of the order 1–2. Contact overflow, the disruption of the clayey soil by the filtration flow in place of its contact with the large-grained heavy soil component, appears when there is present very significant disruptive gradients of the order 10–30 and more, and it is only in the case of very coarse-grained heavy soil (D = 80 – 100 mm) that the disruptive gradients are reduced to 2. Investigation of the changes in humidity in the surface and contact layers in an underwater (flooded) condition, and deformation by peeling connected with these, showed that in clayey soils under water humidity changes over a small range of depth. The bulk of

the soil, under water for a prolonged period (some years), remained unaffected with unchanged volumetric weight and humidity in comparison with its original condition. Increase of humidity and consequent deformation due to peeling takes place because of the wedge-like pressure of thin layers (laminae) of water between the soil particles and its other components. This leads to a situation where the particles diverge from each other, leave the confines (radius) of molecular forces action and the molecular interlinkages cease to function; at this point the peeling of the clayey particles and components begins. The presence of a heavy soil component consisting of coarse sand and gravel particles checks this dangerous phenomenon. On the basis of investigations carried out, author examined the important problem of selecting the materials of correct particle size for reflux filters, heavy loading additions, and the drainage of hydrotechnical installation.

Yu. M. Shekhtman

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2710. Mkhitaryan, A. M., New filtration calculation on an earth dam on a permeable base (in Russian), *Trudĭ Kuibyshevsk. Inzh.-stroit. in-ta* no. 3, 43–63, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4476.

An approximate hydraulic solution is given for calculation of filtration through a homogeneous earth dam on a permeable base for the particular case when the coefficients of filtration of the body of the dam and the base are identical, and the lower slope of the dam has no drain. In this the dam is examined with and without water in the lower level.

Dividing the profile of the earth dam into three parts—upper wedge, central portion and lower wedge—author uses a number of well-known and now obsolete calculation assumptions relating to the form of the lines of currents within the limits of the particular part. Thus the author replaces lines of currents within the limits of the upper wedge by arcs of concentric circumferences [see A. A. Uginchus, Calculation of filtration through earth dams; Stroiizdh, 1940, p. 57] without any references to available literature.

For the lower wedge use is made of N. N. Pavlovskii's solution (formula 4.1) and Bildyug's assumption (formula 4.2), etc., again without any references to the original sources. Therefore there is nothing new in the basic assumption "of the new filtration calculation." As a result, extremely complicated systems of equation which require the construction of special graphs were obtained by the author.

A. A. Uginchus

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2711. Kozin, V. N., Calculation of the gradients of troughs of drain wells when two flows come together (in Russian), *Vodosnabzhenie i San. Tekhnika* no. 4, 26–30, 1955; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4263.

Formulas are proposed for calculating the gradient of the bottom of the trough of a nodal well in which two flows of drain collectors unite into one. Having first assumed, for determination of the depth in the well during fusion of the flows, relationships which were derived for the motion of a fluid with variation of the rate of flow along the path, author then gives these relationships, in the order of their simplification, an empirical character.

Further, author derives an empirical formula for determining the transitional coefficient which he introduced into the theoretical relationships, considering this coefficient dependent on the gradient of the bottom of the trough of a well, and thus obtaines the numerical formulas recommended by him.

According to the author, the depths in the well calculated according to his formula differ from those in the test by not more than 15%.

Paper contains inaccuracies in the formulations, and there are misprints. In the example studied, the depth at the end of the trough is incorrectly determined, since there will be a turbulent flow in the well and the character of the junction of the flow at the end of the trough with the flow at the beginning of the discharge collector will be different.

F. I. Pikalov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2712. Mirzadzhanzade, A. Kh., and Abasov, M. T., An approximate method of solving the problem of injecting a viscous-plastic liquid into the soil (in Russian), *Izv. Akad. Nauk AzerbSSR* no. 5, 23–27, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10677.

The nonlinear problem is investigated which deals with the injection of liquid into a porous medium, saturated by another liquid, in conditions of elastic filtration and at different values for density, viscosity and incompressibility of both liquids. This problem was solved by reviewer for the case when the injected and squeezed-out liquids are viscous [*Izv. Akad. Nauk SSSR, Otd. Tekn. Nauk* no. 5, 1952]. The authors assume that the injected liquid is viscous-plastic and the ejected is viscous. In conformity with this an initial gradient of filtration, depending on the limit of pressure of the shear displacement, is introduced into the kinematic conditions on the separation boundary of the two liquids. Further, with the aid of the method of quasi-stationary conditions, an approximate solution is given for the problem of the motion of two liquids for a semi-delimited region with boundary conditions of the first order (injection into a linear battery of wells at a given pressure of the face). This solution leads to a system of two ordinary differential equations, requiring numerical integration. The approximate method used in the study is applied also to axially symmetrical problems and in boundary conditions of the second order (an assigned yield for the wells).

N. N. Verigin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2713. Salekhov, G. S., Pressure determination in petroleum-bearing heterogeneous strata (in Russian), *Izv. Kazansk. Fil. Akad. Nauk SSSR, Ser. Fiz.-matem. i Tekhn. Nauk* no. 9, 49–52, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10665.

A formula is deduced for the determination of the function of pressure in petroleum-bearing heterogeneous strata when the value $\sqrt{kb}$ (when k is the permeability and b the productive capacity of the stratum) appears to be harmonic, and when the working of the petroleum source is being effected by n wells arbitrarily distributed. The stratum regime is supposed to be a water pressure one, while the motion of the liquid obeys the linear principle of filtration. The article appears to be a more expanded exposition of a previous work by this author.

P. F. Fil′chakov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2714. Glogovskii, M. M., and Rosenberg, M. D., The expulsion of petroleum in gas pressure conditions (in Russian), *Trudĭ Vses. neftegaz. n.-i- in-ta* no. 8, 280–310, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4488.

Authors investigate the process of petroleum expulsion during shaking of gas into a gas cap, both considering and neglecting the viscosity of the gas. The following cases were examined: (1) when the pressure at the face at the injection wells is constant, and (2) when the volumetric discharge of the gas shaken is given as function of time.

They also examine the problems of simultaneous removal of petroleum from a petroleum deposit and of gas from a gas cap, and of removal of petroleum from a seam as a result of the expansion of the gas cap without shaking and removal of gas from it. For all the cases examined, examples of the calculations and graphs are

given. The results obtained are extended to the case of several numbers of operational wells. V. A. Karpychev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2715. Korotkov, S. F., Irrigation of a rectilinear chain of wells in a band-shaped deposit (in Russian), *Izv. Kazansk. fil. Akad. Nauk SSSR, Ser. Fiz.-Mat. i Tekh. Nauk* no. 9, 59–66, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4479.

Considering the conditions of the seam water pressure to be such that the filtration is subjected to Darcy's law, disregarding the difference in velocities and densities of petroleum and water, the author, examining a horizontal seam with constant permeability, porosity and power revealed by complete wells, investigates the case when at an initial instant of time the petroleum fills an infinite band having parallel boundaries, in the middle of which there is an infinite chain of wells having equal outputs. It is also assumed that the original boundary of separation of the liquid coincides with the feeding contour.

The discharge of the wells at constant pressure on the feeding contour and on the face of the wells is determined, as well as the supply of petroleum in the blocks at the instant of irrigation of the wells.

A solution of the problem for the case of both a precise and an approximate satisfaction of the condition at the boundary is given. V. A. Karpychev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2716. Shvidler, M. I., Flow of a liquid to a well having a crevice in the area near the face (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 11, 95–100, 1955; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4486.

Author investigates the steady flow of a liquid into a well and crevice on the assumptions: (1) the crevice extends parallel to the top and bottom of the seam and is equidistant from them; (2) the sand filling the crevice is so porous that it is possible to neglect losses of pressure during motion of the liquid in the crevice in front of the face compared with the pressure at the face and to consider the pressure equal to that at the face all over the surface of the crevice; (3) it is possible to neglect the flow falling on the walls of the face outside the crevice, as compared with the flow to the crevice.

The flow is divided into three parts, viz. (1) plane radial flow from the feed contour to the lateral surface of the crevice; (2) axially symmetrical flow to the upper end of the crevice; (3) flow to the lower end, symmetrical to flow (2). Using the solution of a known problem from the theory of electricity, author finds an expression for the discharge which characterizes the flow of a liquid into the crevice. An example of the calculation is given.

I. V. Krivonosov and V. A. Karpychev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Geophysics, Hydrology, Oceanography, Meteorology

(See also Revs. 2529, 2537, 2538, 2648, 2676, 2682, 2712)

Book—2717. Hollis, E. P., Bibliography of engineering seismology, 2nd ed., San Francisco, Earthquake Engineering Research Institute, 1958, ix + 144 pp. $4.50.

Book is an extension of a preliminary edition (1954), with over 2000 entries of over 800 authors. 1. Sources of data, 11 pp. 2. Geology, geodesy, seismology, seismicity, 45 pp. 3. Seismometry; Dynamics of structures and soils, 43 pp. 4. Design and construction in seismic regions, 42 pp. Many references contain abstracts of a few sentences, and several sections begin with a summary of 1–2 pages. A valuable reference book.

B. Gutenberg, USA

2718. Paria, G., Love waves in hypoelastic body of grade zero, *Quart. J. Mech. Appl. Math.* **11**, 4, 509–512, Nov. 1958.

Author analyzes Love waves, using theory of hypoelastic materials of grade zero proposed by Truesdell [AMR **9** (1956), Revs. 2852 and 2853]. Results are very similar to those obtained from linear elasticity theory, difference being that one normal stress is nonzero according to this theory, zero classically.

J. L. Ericksen, USA

2719. Berryman, L. H., Goupillaud, P. L., and Waters, K. H., Reflections from multiple transition layers, Part I—Theoretical results; Part II—Experimental investigation, *Geophysics* **13**, 2, 223–243; 244–252, Apr. 1958.

Part I: Continuous velocity logs may be approximated by a series of zones in which the velocity is a linear function of the depth. The reflection response of a series of transition layers may be calculated from an iterative-type formula, developed in this paper, which is well suited to digital computer use. This solution takes into account multiple reflections between layers. The reflection output for any input wave shape may be calculated. In this paper a Gram Charlier series pulse having a spectrum peaked at 40 cps is used throughout to facilitate comparison of results.

The dependence of the reflection response of single and double layers on frequency and the reflections for the standard input pulse are illustrated. It is shown that (1) symmetrical double transition layers give an appreciable reflection output even for a base thickness as low as 10 ft; (2) the upper layers of a multilayer group may influence considerably the reflection character from the lower layers.

Part II: It has been shown that the velocity of longitudinal waves in a nylon rod is a linear function of the temperature for the range 20 C to 100 C. Use is made of this property to study reflections from multiple transition layers.

From authors' summary by J. T. Wilson, USA

2720. Pekeris, C. L., and Longman, I. M., Ray-theory solution of the problem of propagation of explosive sound in a layered liquid, *J. Acoust. Soc. Amer.* **30**, 4, 323–328, Apr. 1958.

Wave-type solution is given for the pressure field $p(r, z, t)$ produced by a Heaviside pulse at depth d under surface of liquid (1) depth 4, over liquid (2) of lower or higher sound speed (c). Evaluation is carried out numerically for $z = d = 4/2$ and $c_2 = c_1/1.1$, $\rho_2 = \rho_1$ or $2\rho_1$; or $c_2 = 1.1\,c_1$, $\rho_2 = 2\rho_1$. For $c_2 > c_1$, the solution illustrates features due to diffraction at the lower interface, and at large ranges separation of waves characteristic of the two phases. Reviewer finds some ambiguities in use of symbol R.

S. Paterson, Scotland

2721. Choudhury, M. A., Study of seismic waves from deep-seated earthquakes in the Hindu Kush (in French), *Ann. Geophys.* **14**, 1, 31–75, 1958.

Paper describes J. Coulomb's method [*C. R. Acad. Sci., Paris* **244**, 8, 1060–1062, 1957] for locating epicenter using isochronic pairs. Author thus accurately locates epicenters and origin times of several Hindu Kush earthquakes and notes differences in arrival times of P waves with the tables of Jeffreys and Bullen, particularly in the neighborhood of 20°. He suggests corrections to those tables, not very different from the one suggested by H. Jeffreys [*Geophys. Suppl.* no. 6, 348–364, 1952]. Qualitatively the same conclusions are established for S waves. Arrival times of sP and sS waves suggest that observed longitudinal and transversal waves originate at different times and part of the fault; computed fault propagation speed roughly checks with H. Benioff's value

[*Bull. Seis. Soc. Amer.* **28**, 77-84, 1938]. Author detects a wave probably reflected at Moho discontinuity and two transversal waves 4 and 20 sec after P. E. Rosenblueth, Mexico

2722. Radzievskii, V. A., Problem of the errors and the optimum damping in single-component vibration-measuring apparatus of the seismic type (in Russian), *Dopovidi Akad. Nauk URSR* no. 5, 426-429, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 7543.

The equation of motion is investigated of the sensitive element of an apparatus of the seismic type. For the case of steady motion, expressions were found in the frequency and phase characteristics of the vibrometer, accelerometer and velocimeter. Values were determined for the margin of error in frequency and phase, and a detailed analysis of these was carried out. For the characteristics of the sensitive element in irregular motion an expression is introduced for the transition characteristics. In evaluating the transition error of the apparatus it was shown that the optimum damping is equal to 0.5. M. E. Temchenko

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2723. Chepil, W. S., The use of evenly spaced hemispheres to evaluate aerodynamic forces on a soil surface, *Trans. Amer. Geophys. Un.* **39**, 3, 397-404, June 1958.

Direct and indirect measurements showed a substantial lift force on the surface roughness elements (such as soil grains resting on the surface) in a windstream. Lift was approximately four-fifths of drag on hemispherical roughness elements ranging from 0.16 to 5.08 cm in height. The ratio of lift to drag on the roughness elements of the surface remained essentially constant for any drag velocity of the fluid and any depth of the fluid boundary layer beyond a relatively shallow depth. The depth of the fluid boundary layer, on the other hand, had a profound influence on the magnitude of both lift and drag. This study throws new light on equilibrium condition existing between soil grains and moving fluid at the threshold of movement of the grains.

From author's summary

2724. Raraty, L. E., and Tabor, D., The adhesion and strength properties of ice, *Proc. Roy. Soc. Lond. (A)* **245**, 1241, 184-201, June 1958.

Paper describes a study of the adhesion of ice to various solids. If water is frozen to a clean metal surface the interface is stronger than the ice and fracture occurs within the ice itself. The detailed behavior depends on the stresses developed near the interface. If tensile stresses are high the failure is brittle and the breaking stress is temperature-independent. If the tensile stresses are below a critical limit the failure is ductile, and the breaking stress increases linearly as the temperature is reduced below 0 C. Ductile failure appears to be determined by the onset of a critical creep rate and the variation of breaking stress with temperature may be explained in this way. This view is supported by the observation that small quantities of dissolved salts which increase the creep rate of ice produce a parallel reduction in the adhesive strength.

Surface contaminants on metals reduce the adhesion by a very large factor and it is suggested that this is due primarily to a reduction in the area over which strong metal/ice adhesion occurs.

The adhesion of ice to polymeric materials differs from the adhesion to metals. The interfacial strength appears to be less than the strength of ice and failure occurs truly at the interface.

Friction experiments carried out with clean and lubricated metals and polymers sliding on ice provide a measure of the shear strength of the solid/ice interface. The results show a marked parallelism with those obtained in the adhesion experiments; this again emphasizes the close connection between the friction and adhesion of solids.

This study has some bearing on the de-icing of aircraft and of ships sailing in polar seas. The results suggest that ice layers may be removed most readily if brittle fracture can be achieved. Constraint of the ice inhibits brittle fracture and the forces to produce ductile failure are considerably greater. These forces may, however, be reduced by adding small quantities of suitable salts, since these reduce the resistance to ductile flow if the system is above the eutectic temperature. Finally, hydrophobic materials show a very low adhesion; this is particularly marked in the adhesion of ice to polytetrafluoroethylene.

From authors' summary

2725. Tkachev, A. G., Heat exchange when ice is floating in freely running water (in Russian), *Tr. Leningr. In-ta Kholodil'noi i Moloch. Prom-sti* **4**, 48-57, 1953; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10495.

A description is given, and the results, of an experimental investigation of heat exchange when ice is floating in freely running water. In accordance with the speed of diminution of the radii of the ice cylinders or spheres a determination was carried out of Nusselt's criteria in relation to the criteria of Grashof and Prandtl, assuming that in such conditions every undisclosed source of heat in the floating ice is brought to light. The influence was investigated of the anomaly in the coefficient of the thermal expansion on the coefficient of heat emission. The dependence of the model's diameter on the time factor was examined.

G. S. Glushchko

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Book—2726. Budyko, M. I., The heat balance of the earth's surface [Teplovoi balans zemnoi poverkhnosti] Gidrometerologicheskoe Izdatel'stvo; Washington, D. C., OTS (PB 131692), 1958, vi + 259 pp. $4. (Paperbound)

A summary investigation is made in this treatise of worldwide climatological variations of heat balance and radiation balance components for both land and water surfaces. Annual and diurnal variations of such factors as radiational, turbulent and evaporative heat flux, total short-wave incoming radiation, effective outgoing long-wave radiation and horizontal heat transport in the ocean are presented for various typical climatic regimes. Using heat balance and radiation balance components, water balance computations are made from which such significant hydrological and agricultural parameters as potential and actual evaporation, rainfall-runoff ratios and soil moisture transpiration are evaluated. These results are then discussed in terms of the effectiveness of such land preservation methods as irrigation and construction of shelter belts as well as reservoir design and performance forecasting.

Although some direct measurements of heat and radiation balance components are presented, the climatological values given in the publication are computed from basic observational data of such parameters as cloudness, temperature, humidity, precipitation, wind, etc. Author goes into great detail to give the theoretical justification for such computation, and comparisons are made where possible to illustrate the magnitude of errors that can be expected by utilizing such techniques. As a final step author computed the heat balance for the entire atmosphere, the land, the ocean and the earth-atmosphere system as a whole.

Reviewer believes this to be a highly significant contribution to the field of climatology and one which will be of interest to the student, the meteorologist, the hydrologist and the agriculturalist. Certain inadequacies in the reproduction and translation detract a little from the over-all excellence of the publication and it is hoped that it can appear eventually in text form.

J. R. Gerhardt, USA

2727. Krechmer, S. I., Experimental determination of the characteristics of temperature pulsations in the atmosphere (in Russian), *Tr. Tsentr. Aerolog. Observ.* no. 16, 39–47, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10607.

This is a continuation of the author's experimental investigations on the microstructure of a temperature field in the atmosphere [*Doklady Akad. Nauk SSSR (N.S.)*, **63**, no. 3, 1949]. The same apparatus and procedure were used as in the previous investigations. The measurements were carried out in the summer of 1953 at the experimental field station of the geophysical institute of the Akademiia Nauk SSSR. Some data of previous observations were also used. The distribution curves of the temperature's micropulsations at fixed points disclose sharp asymmetry; the maximum is displaced to the side of positive pulsations. This indicates that the negative pulsations of temperature are met with more rarely, but possess a larger amplitude than the positive, which can be explained by episodal breaches of cold stable masses of air. The curves of distribution of synchronous differences of temperature at two points, at some distance from (the base) l, are proximate to the normal curves of distribution. With increase of the base (l = 2 and 32 cm were observed) the curves of distribution appreciably "spread," that is, the large differences occur more often. For the data of six recordings, with rounding off up to 20 secs, the mean quadratic difference of temperature at two points for each one was examined, that is the root from the structural function of the temperature

$$H(l) = \overline{[T(H') - T(M)]^2}.$$

For l, varying within the limits 0.5 – 50 cm, the results are well described by the formula

$$\overline{H(l)}^{1/2} = 8.2 \cdot 10^{-1} l^{0.32}$$

where the temperature is expressed in *degrees* while l is in cm. The indicator of degree 0.32 is very close to the theoretical value of ⅓ obtained by A. M. Obukhov [*Izv. Akad. Nauk SSSR, Ser. Geogr. i Geofiz.* **13**, 1949, no. 1, and A. M. Yaglom [*Doklady Akad. Nauk SSSR (N.S.)* **69**, 1949]. The coefficient 8.2×10^{-1} *degrees* $cm^{-1/3}$ is several times smaller than the results of its theoretical evaluations and values obtained by the author previously. This is explainable, apparently, by the inadequacy in quality of the recorded material used when rounding off. However, analysis by manual means of the calculations of the structural function with rounding off of the order of several minutes is extremely laborious. Consequently it is desirable to make this analysis automatic, with the view that the apparatus should give direct determinations of the structural functions or the correlated moments.

L. S. Gandan

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2728. Rakipova, L. P., Method of calculating heat advection during atmospheric macro processes (in Russian), *Tr. Gl. Geofiz. Observ.* no. 66 (128), 17–32, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10585.

A formula is proposed for the calculations of advective temperature changes, based on the use of the correlations of the thermal wind. The calculations are carried out on the data obtained from radio soundings; the pressure and temperature, at points between the standard levels, are determined with the aid of an interpolation formula. Examples are furnished of the calculations for the annual course of heat advection for different regions. The results of the thermal advection calculations are compared with the components of thermal balance computed by different methods. S. A. Mashkovich

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2729. Gandin, L. S., and Soloveichik, R. E., Periodic course taken by the temperature when advection is present (in Russian), *Tr. Gl. Geofiz. Observ.* no. 60 (122), 23–31, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10586.

With the aid of the operational method a solution is found for the plane, periodic-with-time problem on the distribution of the disturbance of temperature in the lower atmospheric layer and in the soil when a horizontal advection of the atmosphere is prevailing (the velocity of the wind and the coefficient of turbulent heat conductivity are assumed to be constants; the component of heat balance on the earth's surface, taking place at the expense of radiation, is taken to be assigned in the form of a Fourier series with time, while the coefficients of this series are independent of the horizontal coordinate x; above the windward region ($x \leqslant 0$) the temperature disturbance in the atmosphere and in the soil are assumed to be equal to zero). On the basis of analysis of the solution obtained, a series of qualitative deductions are made, relating to the distribution at x temperature of the underlying surface and the turbulent inflow of heat into the soil. An example is given of the numerical calculation covering the case of thermal equilibrium, changing with time along the cosinusoidal curve. Finally, several possible generalizations of the problem are indicated. L. N. Gutman

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2730. Dobryshman, E. M., The irregular problem of convection by a vertical wall (in Russian), *Tr. Tsentr. In-ta Prognozov* no. 43 (70), 57–63, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10500.

With the help of the method of the finite boundary layer [M. E. Shvets, *Prikl. Mat. Mekh.* **13**, no. 3, 1949] an approximate solution is obtained for the nonlinear irregular problem of the free laminar thermal convection by a vertical semi-infinite wall, the temperature of which appears to be set by the function of time. The wall is assumed to be delimited underneath if its temperature is higher than that of the surrounding temperature, and delimited above in the opposite case. By means of comparison of the precise solution, relating to the case of an infinite wall (when the equations become linear) with the approximate, it was shown that Shvets's method applied to the given problem fully guarantees satisfactory accuracy. L. N. Gutman

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2731. Hess, S. L., Simple forms of the geostrophic and thermal-wind formulae for rapid calculations, *Bull. Amer. Meteor. Soc.* **39**, 4, 228–229, Apr. 1958.

2732. Dobryshman, E. M., Inclination winds under a thermal non-uniform underlying surface (in Russian), *Tr. Tsentr. In-ta Prognozov* no. 43 (70), 49–56, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10609.

2733. Brandejs, S., and Zikmunda, O., Numerical and graphical forecasting of the surface pressure field (in German), *Z. Meteor.* **11**, 10/11, 305–311, Oct./Nov. 1957.

Authors, from Charles University in Prague, describe a method of numerical forecasting a 1000-mb chart and a thickness which is essentially that of Sawyer and Bushby. No examples of actual forecasts are given. M. G. Wurtele, USA

2734. Andreyanov, V. G., Labzovskii, N. A., and Selyuk, E. M., Application of warranty curves in studying wind agitation (in Russian), *Tr. Gos. Gidrolog. In-ta* no. 56 (110), 118–122, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10384.

A criticism of results obtained by B. Kh. Glukhovskii and Ya. G. Vilinskii [*Meteorologiya i Gidrologiya*, no. 9, 1953] when investigating the principles of the distribution of the elements of ocean

wind waves. Results are furnished of the analysis of 119 wave diagrams, refuting the conclusions of these authors regarding the existence of a single generalized dimensionless function for the distribution of the heights of wind waves.

Yu. M. Krylov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2735. Kachurin, I. G., Determination of the structural characteristics of atmospheric flows in natural conditions (in Russian), *Tr. Leningr. Gidrometeorol. In-ta* no. 4, 180–184, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10744.

A description is given of a "turbulemeter" device for the recording of wind velocities of small inertia values and of the vertical component; the device was designed and made in 1951 in the Leningrad Hydrometeorological Institute. As transmitters of the wind velocity, two platinum wires, 20 μ in diameter and of different length, were used as contiguous arms of a Wheatstone bridge, the two remaining arms of which were manganin resistances. These wires are placed horizontally. The transmitter of the vertical component was two identical filaments, placed obliquely adjoining each other, symmetrically with reference to the axis of the windvane. The pressures on the bridges' diagonals are transmitted through dc amplifiers with an amplification coefficient of 4×10^4 onto an electronic ray valve, the recording being done on a moving ribbon of photosensitive paper. As the result of measurements the constant time of the device was estimated at 0.01 to 0.02 sec. It is asserted that the adopted electrical scheme has a smaller temperature coefficient than the known apparatus devised by A. M. Obukhov and S. M. Krechmer, and opens up the possibility of improving somewhat the gradation curve for wind velocity. The defect of the scheme lies in the instability of the dc amplifier. It should be noted that in 1953 a turbulemeter was perfected for measuring the air temperature with no inertia interference.

A. S. Monin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2736. Slobodov, B. Ya., Determination of geopotential heights, the instability energy and reserve of circulation energy (in Russian), *Meteorol. i Gidrologiya* no. 1, 29–32, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10593.

2737. Bykov, V. V., On the equations for the atmosphere's dynamics when taking into account the hypothesis of the quasi-solenoidal function (in Russian), *Meteorol. i Gidrologiya* no. 11, 8–14, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10560.

The question is examined of procedures on methods of calculation for short-term prognoses of the field of pressure, when substituting for the quasi-geostrophic hypothesis the hypothesis of the quasi-solenoidal state, that is of the approximate equality to zero of the horizontal divergence of velocity D. Charni showed that the latter hypothesis to a large extent is suitable for elimination of small-scale fluctuations. More simple is the solution of the question regarding the mean level in which, in the vortex equation, it is possible to disregard the vertical gradient of the vertical velocity. The substitution of the quasi-geostrophic by the quasi-solenoidal state leads to the supplementary consideration of two terms in the divergence equation. This equation appears to be a nonlinear equation of the Monge-Ampere type relative to the current function ψ. The influence of the supplementary terms of this equation can be easily followed and appears to be most prominent near baric centers, and also in regions with a large zonal wind component. An example is given of the distribution of these supplementary terms on pressure level of 700 mb.

Under real conditions the divergence equation appears everywhere to be elliptical in relation to ψ. It can be solved by the customary iteration method, and when so doing it is rational to make use of the geostrophic function in the initial approximation of this method. Another way of solving this equation is proposed, based on taking into account the smallness of the given supplementary terms, that is, on the assumption of the smallness of the declination of the current function from the geostrophical. A method is described of the application of electronic calculating machines for computations from this model. In the general case, applicable to the spatial problem, the quasi-solenoidal factor can also be introduced into the vortex equations, divergence and inflow of heat, while retaining, however, in the vortex equation the term lD (l being Coriolis parameter), substituting for it, as usual, the vertical gradient of the vertical velocity. Combining these equations, two equations can be obtained, containing both the local derivatives from ψ and the absolute geopotential and the linear relatively to these derivatives. One of the above equations is obtainable by differentiating with time of the divergence equation and contains in essence the variable coefficients, which adds considerably to the difficulty of utilizing it.

L. S. Gandan

Courtesy Referativnyi Zhurnal, USSR
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2738. Shvets, M. E., and Kamenskaya, O. A., Method for determining the altitude of the lower boundary of internally massed laminar clouds (in Russian), *Tr. Leningr. Gidrometeorol. In-ta* no. 5–6, 201–207, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10597.

It is assumed that the formation of internally massed clouds depends basically on ascending vertical motions, on turbulent exchange in the boundary layer of the atmosphere, and on the relative humidity near the surface of the Earth. These factors are taken into account when deducing the equation of the transfer of humidity shortage

$$\frac{d\Lambda}{dt} - \frac{\partial}{\partial z} D \frac{\partial \Lambda}{\partial z} = - \alpha w \frac{dq_m}{dT} \qquad [1]$$

where Λ is the humidity deficit, D the coefficient of turbulent exchange, α the parameter, q_m the maximum humidity, T the temperature, w the vertical velocity component, z the altitude, t time. The condensation level is determined from the solution of this equation. In the first case the condensation level is determined without consideration of the turbulent exchange from the solution of the equation

$$w \frac{\partial \Lambda}{\partial z} = - \alpha w \frac{dq_m}{dT}$$

The altitude of the condensation is determined by the formula $H = 1620(1 - r)m$ where r is the relative humidity next the earth. This formula gives smaller values for the condensation altitude. In the second case the following equation is solved

$$\frac{\partial}{\partial z} D \frac{\partial \Lambda}{\partial z} - w \frac{\partial \Lambda}{\partial z} = \alpha w \frac{dq_m}{dT} \qquad [2]$$

with boundary conditions

$$\Lambda = \Lambda_0, \text{ when } z = 0$$

$$\frac{d\Lambda}{dz} = 0, \Lambda = 0, \text{ when } z = H$$

The peculiar case is examined of the solution of equation [2] when $w = az$ and D is a constant. In this case the condensation levels depends on three parameters, r, a/D and T_0.

V. P. Sadokov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2739. Mkhitaryan, A. M., Distribution of atmospheric pressure at sea level and the general circulation of the atmosphere (in Russian), *Izv. Akad. Nauk ArmSSR, Fiz-matem., Estestv. i Tekhn. Nauk*, **9**, 9, 67–96, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10564.

The work consists of two parts. The first part concerns the process of making more precise the equations obtained earlier by the author. This better defined accuracy takes into account the changes with height of the pressure in the boundary layer and of the coefficient of turbulent exchange on the vertical plane (the latter is taken to be a linear function of the altitude). The results are analyzed; in particular, a comparative evaluation is made of the part played by the turbulent agitation in the horizontal and vertical directions. In the second part another method is proposed for determining the pressure on the earth in a given temperature field. Author digresses from the simplified equations of motion (only those terms are retained which contain Coriolis force, the horizontal gradients of pressure and the forces of vertical friction); the equations of continuity, in which is conserved the item with vertical velocity; the static equations and those of Clapeyron. Author finds from the equations of motion the horizontal components of velocity as functions of the pressure. Then with the help of the obtained correlations expressions are recorded for

$$\left[\nu \frac{\partial \rho v_\theta}{\partial z}\right]_{z_0}^{\infty}, \quad \left[\nu \frac{\partial \rho v_\lambda}{\partial z}\right]_{z_0}^{\infty} \quad \left(\nu = \frac{\mu}{\rho}\right) \qquad [*]$$

Here z is the vertical coordinate, v_θ and v_λ are the meridianal and latitudinal components of velocity, ρ the density, μ the coefficient of turbulent viscosity. The equations of motion are integrated with z from z_0 to ∞, and for the equalities obtained the formulas found for values [*] are substituted. Correlations are obtained linking

$$\int_{z_0}^{\infty} \rho v_\theta dz, \quad \int_{z_0}^{\infty} \rho v_\lambda dz \qquad [**]$$

with an unknown (so far) pressure. Further, author integrates with z from 0 to ∞ the equations of continuity, making use as boundary conditions of the parity with zero of the vertical velocity w when $z = 0$ and of the parity $\rho w = 0$ when $z = \infty$. In the equations derived in this manner the above-mentioned expressions are substituted for the values [**]. The correlations obtained, together with the barometrical formula, enable author to construct equations for the determination of the pressure at the earth's surface.

S. A. Mashkovich

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2740. Tkachenko, A. V., Problem of the determination of the coefficient of turbulent viscosity in the boundary layer of the atmosphere (in Russian), *Tr. Gl. Geofiz. Observ.* no. 60 (122), 53–59, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10618.

Assuming that the coefficient of turbulent viscosity k in the boundary layer of the atmosphere (higher than a certain level $z = H$) is a constant, the stationary distribution of wind with altitude is described by the so-called Eckman spiral, the equations of which in parametrical form can be recorded as

$$\frac{c'}{u_g'} = (1 - 2e^{-\lambda z'} \cos \lambda z' + e^{-2\lambda z'})^{1/2}$$

$$\operatorname{tg} \alpha' = e^{-\lambda z'} \sin \lambda z' \, (1 - e^{-\lambda z'} \cos \lambda z')^{-1},$$

where c', α' are the modulus of the wind vector (calculated from its value at level H) and the angle formed by this vector with its limiting direction when $z \to \infty$

$$u_g' = u_g - u_H, \quad z' = z - H, \quad \lambda = \sqrt{\omega \sin \phi / k}$$

(ω is the angular velocity of the Earth's rotation, ϕ is the geographical latitude). Another form of the parametric presentation of Eckman's spiral is served by the equations

$$r = u_g' e^{-\lambda z}, \qquad \operatorname{tg} \beta = \operatorname{tg} \lambda z'$$

where r, β are the polar coordinates of the spiral in a computing system where the pole is at a point corresponding to the value of a gradient wind, and with the polar axis directed from the pole to the point, corresponding to the value for the wind at level H. The equations introduced permit $\lambda z'$ to be expressed through any of the values c'/u_g', α', r, β in the form of $\lambda z' = F(y)$, whence $\lambda = \partial F(y)/\partial z$. With the value of λ known it is not difficult to determine k. Nomograms are given, enabling the relevant calculations to be presented in graphical form.

A. S. Monin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2741. Musaelyan, Sh. A., Waves, originating in an atmospheric flow because of mountain barriers (a spherical space problem) (in Russian), *Trudi Tsentr. In-ta Prognozov* no. 43 (70), 19–28, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8034.

An investigation is made of the adiabatic motion above the earth's sphere. Boundary conditions assumed are: (1) the pressure disturbance at a certain height is equal to zero, (2) there is air slip along the earth's surface. The method of long waves is used. The system of equations, as also the second of the boundary conditions cited above, is linearized by the method of small disturbances; the linearization is carried out relative to a pure zonal circulation. Author merges the problem with the solution of one equation for pressure. This equation contains a parameter substantially dependent on the size of the irregularities of the earth's surface. It appeared possible to examine separately two extreme cases: (a) large hills; (b) small hills. Analysis establishes the fact that in the case of large hilly ridges (of the type of the Rocky Mountains) pressure disturbances are formed, representing waves superimposed on the Western flow. The amplitude of such a wave decreases with height in accordance with the exponential principle. In the case of small hills, three-dimensional waves are formed, the amplitude of the wave changes with height, not according to the exponential principle but according to the sinusoidal.

S. A. Mashkovich

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2742. Dmitriev, A. A., Some problems regarding the dynamics of cyclones viewed as vortex columns in a heterogeneous field (in Russian), *Trudi Mor. Gidrofiz. In-ta Akad. Nauk SSSR* **6**, 33–42, 1955; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8038.

As a development of the classical statement of the problem by S. A. Chaplygin, author determines the forces which act on the vortex of the end plane section of a flow with a heterogeneous field of velocities for some particular instances; e.g. (1) an immovable vortex in the velocity field of another vortex with superimposition (on it) of a homogeneous flow; (2) an immovable vortex in the hyperbolic point of the velocity field produced by two vortices with different circulation (of one sign); (3) a vortex describing the circumference about the center of another vortex. In the last case when there is in existence a natural velocity of the vortex column (relative to the motion created by the external vortex), an expression is found for the additional force reacting on the vortex $\Delta F = -\rho \tilde{\gamma} (v_\Gamma - v_\omega)$ where γ is the additional circulation of the vortex in motion, v_Γ is the velocity produced by the leading vortex, v_ω is the velocity of the circular motion of the vortex column. In so doing, the following structure for the vortex column is assumed

$$v = \frac{\gamma r}{2\pi r_0^2} \quad (r \leq r_0)$$

$$v = \frac{\gamma}{2\pi r} \quad (r \geq r_0)$$

In the study use is made of the known procedure of the theory of the plane motion of liquids. P. S. Lineikin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Naval Architecture and Marine Engineering

(See also Rev. 2445)

2743. Yamazaki, R., On the theory of screw propellers (in Japanese), *J. Soc. Nav. Arch. Japan* no. 103, 99–105, July 1958.

Applying the theory of free-running screw propellers developed in the present author's previous papers [*J. Soc. Nav. Arch. Japan*, nos. 100 & 101], the influence of various factors on screw propeller characteristics were studied.

The effects of blade outline and blade area are calculated and the results show good accordance with experimental trend.

From author's summary by T. Inui, Japan

2744. Kostyukov, A. A., On optimum distribution of displacement of a ship along its length (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 6, 133–135, June 1957.

Author uses simplified wave-resistance formula of M. D. Khaskind [title source no. 10, 108–112, 1956] and own previous work [title source, no. 10, 166–169, 1955] to obtain the dependence on Froude number of optimum longitudinal fullness distribution and prismatic coefficient. The limited results agree with Taylor's findings.

In a review of this paper, Khaskind notes related work by Wustrau [*Schiffstechnik* **3**, 16, 223–224, 1956] for ships of given displacement. A. G. Fabula, USA

2745. Perekhval'skii, V. S., Construction of a field of velocities behind a ship moving in a canal (in Russian), *Tr. Novosibir. In-ta Inzh. Vod. Transp.* no. 2, 47–60, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10410.

An approximate solution is given of the problem on the determination of a field of velocities behind a ship. The velocities are investigated which have resulted from the working engine (by propeller or paddle wheel) in a restricted flow of liquid, and also the velocities of the running current induced by the vessel. The formulas obtained tally with the case of a self-propelled ship of sufficiently low velocities, inasmuch as the influence of the free surface of the water is only taken into account as the influence exercised by a solid wall. On the basis of the calculations carried out, a deduction is arrived at regarding the real influence of limited dimensions of the water basin on the velocity due to the engine and the velocity of the current. A. A. Kostyukov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Friction, Lubrication and Wear

(See also Revs. 2457, 2724)

2746. Horn, H., Practical investigation of the diminishing of causes of wear in rocking-lever operated valve controls (in German), *Maschinenbau-Technik* no. 5, 270–276, May 1957.

Following up previous theoretical work, an experimental set-up for measuring friction forces between rocker and valve stem is described. Results indicate superiority of a roller on the rocker, as opposed to direct contact of rocker and valve stem. Author suggests using a roller with a needle bearing as most economical construction in the long run. A. S. Hall, USA

2747. Stoll, H., Wear experiments with radio-active piston rings (in German), *Motortech. Z.* **19**, 2, 41–44, Feb. 1958.

2748. O'Donnell, G. J., Viscoelasticity in lubrication, ASME Ann. Meet., New York, N. Y., Nov.–Dec. 1958. Pap. 58-A-201, 3 pp.

We need to know how viscoelasticity is involved in such mechanisms as high-speed gears and bearings. We need to know under what conditions various fluids display viscoelasticity. This information could have immediate value in designing high-speed machines and their lubricants. From author's summary

2749. El-Sisi, S. I., and Shawki, G. S. A., Performance characteristics of lubricating oil film between disks, ASME Ann. Meet., New York, N. Y., Nov.–Dec. 1958. Pap. 58-A-254, 12 pp.

A testing machine has been designed to investigate the performance of the lubricating oil film between two independently driven circular disks in line contact under conditions of combined rolling and sliding, in an endeavor to study the behavior of meshing gear teeth with adequate supply of lubricant. Test results show that the ratio of sliding to rolling velocity is a prime factor in the behavior of rotating disks. Values of this ratio equal to zero and unity (conditions of pure rolling and pure sliding, respectively) give rise to critical changes in the performance of the disks, being most favorable, from a lubrication viewpoint, at pure rolling (i.e., at the gear pitch-line), and least favorable at pure sliding where scuffing of surfaces may well be expected. Recent theoretical investigations do not seem to be able yet to account for salient results obtained in the present study. Further work on the subject is proceeding. From authors' summary

2750. Siripongse, C., Rogers, P. R., and Cameron, A., Thin film lubrication. I—Discharge through thin oil films; II—Lubrication of the four ball machine, *Engineering* **186,** 4821, 146–149, Aug. 1958.

Voltage drops across oil films were measured as a function of film thickness for both static and dynamic setups. The voltage drop is independent of viscosity and speed, but very sensitive to impurities in the oil. Using these data, it was found that complete oil films existed between the balls in a four-ball machine. Friction measurements and the film thickness data enabled calculations of mean viscosities in the contact area to be made. The pressure required to produce this viscosity, assuming an exponential viscosity-pressure relationship, compared favorably with the Hertzian pressure. W. J. Anderson, USA

2751. Hays, D. F., A variational approach to lubrication problems and the solution of the finite journal bearing, ASME Semiann. Meet., Detroit, Mich., June 1958. Pap. 58-SA-54, 33 pp.

Author presents a technique, based upon direct method of variational calculus, for deriving an analytical solution to Reynolds equation in two-dimensions; series solutions are obtained. Method is applied to finite journal bearing with continuous film. Design charts are given describing characteristics of bearing.

G. Power, England

2752. Rabinowicz, E., New techniques revealed at West Coast Lubrication Conference, *Prod. Engng.* **29,** 46, 84–85, Nov. 1958.

Books Received for Review

ASHBY, R. J., and CHILVER, A. H., Problems in engineering structures, New York, St. Martin's Press, Inc., 1958, iv + 168 pp. $4.50.

BENDAT, J. S., Principles and application of random noise theory, New York, John Wiley & Sons, Inc., 1958, xxi + 431 pp. $11.

BERKNER, L. V., (editor), Annals of the International Geophysical Year. Vol. VI, Manual on rockets and satellites, New York, Pergamon Press, 1958, xx + 508 pp. $25. (paperbound)

BROWN, A. I., and MARCO, S. M., Introduction to heat transfer, third edition, New York, McGraw-Hill Book Co., 1958, xvi + 332 pp. $6.75.

Creep and recovery, A seminar on creep and recovery of metals held during the 30th National Metal Congress and Exposition, Cleveland, Oct. 6–12, 1956; Cleveland, Ohio, American Society for Metals, 1957, iii + 372 pp. $7.50.

DAVIES, M., and VERHULST, M., (edited by), Operation research in practice, New York, Pergamon Press, 1958, ix + 201 pp. $12.

DICKSON, L. E., Linear groups with an exposition of the Galois field theory, (unabridged and unaltered republication of 1900 edition), New York, Dover Publications, 1958, xvi + 312 pp. $1.95. (paperbound)

FABRI, J., LEFEBVRE, A. H., LUTZ, O., and THRING, M. W., Combustion and propulsion third AGARD Colloquium: Noise, shock tubes, magnetic effects, instability and mixing, Combustion Colloquium held at Palermo, Sicily, March 17–21, 1958, New York, Pergamon Press, 1958, xii + 614 pp. $20.

FEINSTEIN, A., Foundations of information theory, New York, McGraw-Hill Book Co., 1958, x + 137 pp. $6.50.

HAUSNER, H. H., (edited by), Modern materials—advances in development and applications, Vol. I, New York, Academic Press, Inc., 1958, xi + 402 pp. $12.50.

HAYTHORNTHWAITE, R. M., (edited by), Proceedings of the Third U. S. National Congress of Applied Mechanics, Brown University, June 11–14, 1958; New York, American Society of Mechanical Engineers, 1958, xxvi + 864 pp., 103 papers. $20.

HERFORTH, L., and WINTER, H. M., Ultraschall Grundlagen und angendungen in Physik, Technik, Industries, Biologie und Medizin, Leipzig, B. G. Teubner Verlagsgesellschaft, 1958, vii + 24 pp. DM 12.

HINE, C. R., Machine tools for engineers, second edition, New York, McGraw-Hill Book Co., 1959, ix + 445 pp. $7.75.

JAEGER, C., Engineering fluid mechanics, second edition (first edition in German), New York, St. Martin's Press., Inc., 1957, xviii + 529 pp. $11.50.

LANGER, R. E., (edited by), On numerical approximation, Proceedings of a symposium conducted by the Mathematics Research Center, U. S. Army at the University of Wisconsin, Madison, April 21–23, 1958; Madison, Wis., The University of Wisconsin Press, 1959, x + 462 pp. $4.50.

MCCUSKEY, S. W., An introduction to advanced dynamics, Reading, Mass., Addison-Wesley Publishing Co., Inc., 1959, viii + 263 pp. $8.50.

MATHESON, W. G., (editorial supervisor), Fourth National Symposium on Vacuum Technology, Transactions, Boston, Mass., Oct. 9–11, 1958; New York, Pergamon Press, 1958, 176 pp. $12.50.

MILES, J. W., The potential theory of unsteady supersonic flow, New York, Cambridge University Press, 1959, xii + 220 pp. $8.50.

PIRSON, S. J., Oil reservoir engineering, second edition, New York, McGraw-Hill Book Co., 1958, x + 735 pp. $14.

PRESS, H., Talsperren. Part I. Stauanlagen und Wasserkraftwerke, second enlarged edition, Berlin, Verlag von Wilhelm Ernst & Sohn, 1958, xii + 395 pp. DM 54.

RICHTMYER, R. D., Difference methods for initial-value problems (Interscience tracts in Pure and Applied Mathematics no. 4) New York, Interscience Publishers, Inc., 1957, xii + 238 pp. $6.50.

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Russian literature on satellites. Part I, New York, International Physical Index, Inc., 1958, 181 pp. $10. (paperbound).

SCHULZ, H., Die Pumpen Arbeitsweise, Berechnung, Konstruktion fur Studierende des Maschinenbaus und zum Selbststudium, tenth enlarged edition, Berlin, Springer-Verlag, 1959, vii + 248 pp. DM 19.50.

SOLODOWNIKOW, W. W., Grundlagen, der selbsttatigen Regelung. Vol. I. Allgemeine Grundlagen der theorie linearisierter selbsttatiger Regelungssystems, Munchen, R. Oldenbourg, 1959, xvi + 727 pp. + 460 illus. + 23 tables. DM 65.

URQUHART, L. C., and O'ROURKE, C. E., Design of concrete structures, sixth edition, New York, McGraw-Hill Book Co., 1958, ix + 546 pp. $8.

WEBER, C., and GUNTHER, W., Torsiontheorie, Braunschweig, Friedr. Vieweg & Sohn, 1958, 306 pp. DM 38.

WHITE, D. C., and WOODSON, H. H., Electromechanical energy conversion, New York, John Wiley & Sons, Inc., 1959, xv + 646 pp. $12.50.

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Published 1958. $20.00 to members and nonmembers.—Within this 904-page volume are reports of important studies in the fields of dynamics, vibration, elastic waves, elasticity, elastic structures, plasticity, viscoelastic flow, fracture, fluid flow, aerodynamics, and heat transfer. There are also discussions of new concepts and methods, and a large amount of new data which will aid in generating new ideas and new approaches toward solving other problems of the applied mechanics field. The information was presented by 155 well-known engineers at the June 1958 congress.

MECHANICAL IMPEDANCE METHODS FOR MECHANICAL VIBRATIONS

Published 1958. $5.50.—Shows how impedance methods apply to lumped and continuous systems of simple and moderate complexity, reviews measurement techniques, demonstrates the power of digital computers by comparing the calculated and measured characteristics of a highly symmetrical system of moderate complexity, gives measured values of typical structures of large size and high complexity, discusses the importance of the impedance in influencing shock and vibration spectra measured in field service, indicates how to apply impedance methods to the calculation of vibration insolator effectiveness, treats impedance of some disordered systems, and illustrates how impedance methods may be used to find the response to random excitation.

SHOCK AND VIBRATION INSTRUMENTATION

Published 1956. $5.00.—This book provides a fund of useful information on recent advances and new concepts in the technology of shock and vibration. Among the subjects discussed are random vibration, effect of non-rigid structures on vibration isolation, hysteresis and slip damping, vibration and shock testing, design approaches and analog methods. CONTENTS: Evaluation of Mounts Isolating Nonrigid Machines from Nonrigid Foundations. Experimental Study of the Effects of Foundation Resilience on Vibration Isolating. Effect of Material and Slip Damping on Resonance Behavior. Shock and Vibration Environments. Mechanical Design for Random Vibration and Shock. Influence of Electrical and Motional Impedance on the Control and Performance of Some Vibration Machines. Shock Testing Machines and Procedures. Damaging Potential of Shock and Vibration. High Speed Computing Methods for Shock and Vibration Problems.

METALS ENGINEERING: PROCESSES

Published 1958. $13.50.—Presents detailed data on the various processes by which metals are converted into finished products. For each of the manufacturing methods, there is a compilation of the basic physical characteristics to be considered and the general advantages and limitations usually encountered. Concise, parallel data concerning the suitability of various metals for each process, and the tolerances on size and surface finish obtainable are included.

ENGINEERING TABLES

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THERMODYNAMIC AND TRANSPORT PROPERTIES OF GASES, LIQUIDS AND SOLIDS

Published1959. $12.50.—Provides a wealth of information that can be profitably applied to the solution of many problems in various areas demanding a knowledge of thermal properties of materials. Specifically, the book surveys the present theoretical and experimental state of the science; reports a large amount of data on experimental and theoretical techniques; reviews and evaluates the present state of knowledge in the specific areas covered; and indicates the gaps of knowledge existing in both transport and thermodynamic properties, particularly at high temperatures and at high or even moderate pressures. The information was originally presented at a Symposium sponsored by the Standing Committee on Thermophysical Properties of the ASME Heat Transfer Division in February, 1959.

PROCEEDINGS OF THE CONFERENCE ON LUBRICATION AND WEAR

Published 1958. $23.00—Here is the complete record of the 1957 Conference arranged by the Institution of Mechanical Engineers with the collaboration of the ASME for the purpose of evaluating current lubrication knowledge, bringing out the findings of important experiments conducted in the United States, Canada, United Kingdom, and Europe; and obtaining the views of those participating in the discussion. Subjects dealt with include hydrodynamic lubrication, boundary friction, boundary lubrication, bearing metals, novel bearing materials, glands and seals, solid lubricants, surface treatments, ball and roller bearings, gear lubrication, engine lubrication, miscellaneous lubricants and applications, additives, and wear. The 34 papers on the latter subject cover laws of wear rate; mechanism of wear; testing of materials for resistance to wear; surface films; effective temperature and environment; wear due to abrasion, fretting, scuffing, pitting; wear on cutting tools; wear in engines, gears, etc.; influence and nature of rubbing surfaces.

THERMODYNAMIC PROPERTIES OF COMPRESSED WATER

Published 1957. $2.50.—Here is a chart that fills the need for an accurate and convenient presentation of the thermodynamic properties of compressed water. These properties which include temperature, pressure, specific volume, enthalpy and entropy, are presented graphically in a large scale chart broken up into fifteen plates. The temperature range covered is from 32 to 705.4°F and the pressure range, from 0.08854 to 6000 PSIA.

METALS ENGINEERING: DESIGN

Published 1953. $10.00.—This book discusses the essential properties which need to be evaluated by the design engineer in his selection of one material over another. Comprising 48 sections and written by 43 well-known authorities, it deals with the over-all problem of selection of material and takes up such specific items as high temperature considerations, plasticity, residual stresses, vibration, fatigue, shot peening, cold working, nitriding, flame strengthening, impact, corrosion, non-destructive testing, surface finish and mass production, and design theory and practice.

METALS PROPERTIES

Published 1954. $11.00.—Provides, in convenient charts and tables, data on a broad range of metals in common industrial use —AISI steels, ASTM steels, cast copper alloys, aluminum alloys, tin, magnesium, etc. Tabulated under each of the more than 500 metals listed is such information as the chemical composition of the metal; its brittleness, heat treatment and other characteristics; its industrial uses; treatment temperatures for forging, annealing, quenching, etc.; such technological properties as recrystallization temperature and hot working temperature, and a great deal of other pertinent information to help the designer choose the proper metal for each part or product.

FLUID METERS, THEIR THEORY AND APPLICATION

Published 1959. $8.00.—This Fifth Edition includes information on a number of new types of fluid meters and metering procedures that have been developed in recent years. It is divided into three sections with the first giving the classification and nomenclature of fluid meters, together with definitions of special terms and other general information. The theory of fluid measurement and the steps taken to develop practical working equations from the theoretical relations are set forth in the second section. Figures and tables for use in solving practical fluid measurement problems, along with examples illustrating their proper use, are contained in the third section.

FLOW MEASUREMENTS (*Chapter 4, Part of 5 Instruments and Apparatus*)

Published 1959. $5.00.—These rules apply when the primary element is an orifice, a flow nozzle, or a Venturi tube. The fluid may be compressible or incompressible. The primary element may be installed within a continuous section of pipe flowing full, or at the inlet or exit of a plenum chamber. Specifically this Chapter includes information on the construction of these three primary elements, the recommended techniques governing tests, the necessary equations for computing rate of flow, examples to illustrate the application of typical data, a discussion of tolerances applicable to certain of the factors involved in the measurements, and an outline of the major advantages and disadvantages of various types of primary elements.

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Published 1957. $20.00.—This is an index to the technical papers published in the ASME Transactions, the Journal of Applied Mechanics, and Mechanical Engineering for the past seventy-seven years. It is divided into two parts with the first covering the papers published between 1880 and 1939, and the second, indexing those published from 1940–1956. Each part has a subject and an author index. The former lists the titles of the papers chronologically under as many headings as are necessary and includes numerous cross-references to direct attention to related material. The alphabetically arranged authors' index gives the headings and the year under which each paper is listed in the subject index.

VISCOSITY OF LUBRICANTS UNDER PRESSURE

Published 1954. $3.00.—This publication reviews and coordinates twelve experimental investigations, made over a period of thirty-five years, on 148 lubricants comprising of 25 fatty oils, 94 petroleum oils, 17 compounded oils and 12 other lubricants. Data are coordinated by means of sixty tables in which the results originally appearing in diversified units are compared. The methods proposed for correlating viscosity-pressure characteristics of oils with properties determined at atmospheric pressures are reviewed and illustrated. Experimental work on heavily loaded bearings, lubrication calculations, and additional techniques for viscosity are covered. Conclusions and recommendations are presented. Computation of the temperature coefficients of viscosity and the method of computing pressure coefficients are also given.

DIAPHRAGM CHARACTERISTICS, DESIGN AND TERMINOLOGY

Published 1958. $3.75.—This Manual defines a diaphragm and its performance characteristics, describes methods of measuring and representing them, shows how they are related and used, describes and illustrates the effects of design details and manufacturing methods on the characteristics. In the appendixes, the terms and notation used are defined, the equipment and methods of testing described, applications of the diaphragms classified and equations given.

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